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An Assessment of the west coast of Newfoundland (NAFO Division 4R) herring stocks (1973 to 1996)

by

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Abstract

Both spring- and autumn-spawning herring are found along the west coast of Newfoundland (4R). These stocks are exploited from April to December mainly by large and small purse seiners and to a lesser extent by fixed gillnetters. The 1997 assessment indicates that their stock status is generally healthy. Relatively young year-classes are in abundance among both the spring- and autumn-spawning herring in the purse seine fishery, as well as in the research surveys, and a high proportion of very old fish still appear in the catch. The 1995 fall acoustic survey estimated the minimum abundance of herring available along the west coast at that time at approximately 84,000 t.

It is concluded that the current TAC of 22,000 t of spring- and autumn-spawning herring would not appear to be excessive. Catches in recent years have been below this level due mainly to the closure of the St. George's Bay spring fishery and poor fishing conditions in the fall. The appearance of the strong 1990 year-class in the spring gillnet fishery in 1996 suggests that there is no longer a biological rationale for the continued exclusion of commercial fishing from St. George's and Port-au-Port Bays. It is recommended that the reopening of these bays to commercial fishing proceed with caution, with areas of known spawning activity remaining closed to intensive fishing. It is further recommended that fishing effort be spread out along the coast and throughout the year as much as possible to avoid directed fishing on any one local spawning component.

Résumé

Les deux groupes de fraie de printemps et d'automne de hareng se retrouvent le long de la côte ouest de Terre-Neuve (4R). Ces stocks sont annuellement exploités d'avril à décembre principalement par les grands et petits senneurs et dans une moindre mesure, par les pêcheurs utilisant des filets maillants. L'évaluation de 1997 indique qu'en général ce stock est en bonne santé. On trouve en abondance dans les captures à la senne et dans les relevés de recherche des classes d'âge relativement jeunes chez les reproducteurs de printemps et d'automne. De plus, une grande proportion de poissons très âgés est encore présente dans les captures commerciales. Le relevé acoustique de l'automne 1995 a estimé à ce moment l'abondance minimum du hareng disponible le long de la côte ouest à approximativement 84,000 t.

Il a été conclu que l'actuel TAC de 22,000 t de reproducteurs de printemps et d'automne n'apparaîtrait pas excessif. Les captures des dernières années ont été sous ce niveau dû principalement à la fermeture de la pêcherie du printemps de la baie Saint-Georges et des conditions difficiles de pêche de l'automne. L'arrivée de la forte cohorte de 1990 dans la pêcherie du printemps au filet maillant suggère qu'il n'y a plus de raisons biologiques pour interdire la pêche commerciale dans les baies Saint-Georges et de Port-au-Port. Il est recommandé que la réouverture de la pêche commerciale dans ces baies se fasse prudemment, tout en interdisant une pêche intensive sur les frayères. Il est de plus recommandé de répartir l'effort de pêche le long de la côte et au cours de l'année afin d'éviter de diriger la pêche spécifiquement sur une des composantes de fraie locales.

Introduction

Within most of the distributional range of northwest Atlantic herring (*Clupea harengus* L.) including the west coast of Newfoundland (NAFO division 4R) we can find herring populations which spawn either in the spring (April to June) or in the autumn (July to October). In addition, within each seasonal-spawning population (or stock), there are local spawning populations (or components) associated with specific spawning areas. Examples of spring-spawning components can be found in St. George's Bay, Port-au-Port Bay and St. Paul's Inlet (Figure 1). These local components intermix throughout the distributional range of the population, although most evidence suggests that once an individual fish spawns with a given local spawning component, it will return to spawn with that component year after year (Blaxter 1985). A local spawning component can therefore be considered as the basic biological unit to be protected from overexploitation. Local spawning components are however not independent of each other, as recruiting individuals may not spawn with their parental spawning component, but may be adopted by another local component, either with the same or a different spawning season (McQuinn, 1997a). All the local components which together occupy a common geographic range, as delimited by their annual migration patterns, constitute the overall population (or metapopulation) which in turn defines the management area (McQuinn, 1997b).

In the NAFO division 4R management area, we are presently unable to determine to which local component an individual fish belongs when it is caught outside of the spawning season. The basic management unit has therefore been defined as the seasonal-spawning stock, which can be determined from the stage of gonad development. The major spawning areas for the spring-spawning stock are located at the southern end of the coast in and around St. George's Bay (4Rd) and Port-au-Port Bay (4Rc) although several other spawning sites are known along the coast towards the north. Mature herring arrive and spawn in these areas from the end of April to the middle of June before dispersing. Autumn spawning is concentrated mainly north of Point Riche (4Ra) from mid-July to mid-September (Figure 1). At other times of the year, these two spawning stocks are mostly found in mixed schools in either feeding or overwintering areas. The major feeding areas, i.e. off St. George's Bay in the spring, north of Point Riche and in the Strait of Belle Isle in the summer and off Bonne Bay in the fall, are associated with concentrations of copepods (red-feed) and/or euphausiids (krill) which are their main food items. Based on winter research survey data (McQuinn and Lefebvre 1995b), they are believed to overwinter in the deeper waters of the Esquiman Channel (Figure 2).

Description of the Fishery

Management Plan

Total allowable catches (TAC) have been in effect since 1977. Since 1981, 45% of the TAC has been allocated to the fixed gear sector and 55% to the mobile gear sector. In addition, the purse seine quota has been allocated proportionately among the half-dozen active vessels and the gillnet allocation has been divided evenly between the regions north and south of Cape St. Gregory. Since 1989, an additional inshore allocation has been made for the small-purse-seine fishery. The

allocation for this gear sector has come from the inshore (fixed gear) quota and was increased from 2,000 to 4,800 t from 1989 to 1994.

Since 1987, the advised target fishing level has been exceeded only in 1991 (Figure 3). In 1994, a cap of 5,400 t of spring spawners was imposed as a conservation measure for the St. George's Bay component of the spring-spawning stock. In 1995, this spring-spawner cap was lifted, in favour of a delayed opening (June 15) of St. George's Bay and Port-au-Port Bay to fishing to protect these local spring-spawning components in accordance with the recommendations of the west coast Herring Co-management Group (McQuinn and Lefebvre, 1995a).

Total Catches

Since 1986, total herring landings from the west coast of Newfoundland averaged 17,300 t (from 12,400 t to 26,400 t) as compared to an average of 14,100 t for the previous decade (Table 1; Figure 3). In 1996, total landings were limited to 14,700 t due mainly to the closure of the St. George's Bay spring fishery, and to poor fishing conditions in the fall (e.g. herring close to bottom and high winds).

Herring catches in western Newfoundland are taken mainly by large (>85') and small (<65') purse seiners and to a much lesser extent by fixed gillnetters from April to December on both spawning and overwintering concentrations. Between 1988 and 1995, 90 to 98% of the total catch was taken by the purse seiners (Figure 4). This proportion dropped to 83% in 1996 due to a more active summer gillnet fishery.

The Purse Seine Fleet

From 1984 to 1987, up to 80% of catches from the large purse-seine fleet were taken from October to December on over-wintering concentrations of herring in areas 4Rb and 4Rc (Figure 5a). In 1988, the development of an over-the-side market to Russian vessels contributed to a considerable increase in landings in the spring fishery in the St. George's Bay/Port-au-Port area from approximately 2,000 t in 1987 to 16,000 t in 1991 (Table 2a). This spring purse-seine fishery accounted for over 70% of the total catch in 1990 and 1993 (McQuinn and Lefebvre 1996a). This proportion has diminished to below 40% since 1994 when St. George's and Port-au-Port Bays were closed to commercial fishing during the spawning season. Annual landings from small purse seiners have ranged between 2,800 t and 3,800 t since 1993 (Table 2b).

In 1996, purse seine fishing was concentrated around Port-au-Port Bay in May (Figure 6). Fishing activity then moved northward towards the Bay of Islands in June as in 1994 and 1995 (McQuinn and Lefebvre 1996a), as well as around Bonne Bay. In the late fall (September to November) herring schools were dispersed, as has been seen in recent years, and fishing was much more spread out along the coast. As in 1994 and 1995, relatively good catches were again recorded in St. George's Bay in October.

The Gillnet Fleet

The inshore gillnet fishery is predominantly oriented toward supplying bait for the active lobster fishery. Due to this limited market demand, reported landings from the fixed gear sector

have generally been below 10% of the total 4R landings since 1985 (Figure 4). Recorded landings from 1990 to 1994 ranged between only 140 and 840 t (Table 2c). There has been an improvement in sales in the northern areas in recent years which has increased the proportion of the catch from 4Ra (Figure 5b) as well as increasing the total landings from 1,700 t in 1995 to 2,300 t in 1996.

Biological Characteristics

Data collection and Analysis

Random samples covering most of the major commercial landings were collected by port samplers and by index gillnet fishermen (Annex 1). These samples were frozen and sent to the Maurice Lamontagne Institute (MLI) in Mont-Joli, Quebec for analyses (i.e. length, weight, gonad weight, maturity stage and age determination).

Individual herring were assigned as either spring or autumn spawners by relating the maturity stage, estimated from a gonadosomatic index model (McQuinn 1989), to the date of capture, using the 4R maturity cycle chart (McQuinn 1987a). In the case of immature fish, otolith characteristics were used as described by Cleary *et al.* (1982). Ages were determined from the otoliths by counting the number of winter rings for spring spawners and the number of winter rings plus one for autumn spawners (Cleary *et al.* 1982). All herring aged 11 years or more were aggregated into an 11+ age-group. The catch at age was generated (CATΔAGE v1.0, Anon 1986) for spring and autumn spawners as described by McQuinn (1987b), weighing the age compositions by the corresponding landing as grouped in Annex 1.

Since 1994, it has become more and more difficult to distinguish these latter year-classes in the catch at age. This has lead us to suspect an error in the age attribution in the past couple of years. The distinction of the winter annuli seems to have degraded since 1992 or 1993 when these herring stocks were exposed to colder annual temperatures (Gilbert *et al.*, 1996). In this respect, the length frequency data appear more reliable, and it is easier to follow the major year-class with these data.

Spawning Stock Proportions

The proportion of each spawning stock in the catches varies among areas and seasons, as well as between the inshore and the offshore, as shown by differences between the gillnet and purse seine samples. In the spring (May and June), herring schools fished by gillnets in and around the major bays in the south near the spawning beds are typically dominated by spring spawners (Table 3, Figures 6a,b). Gillnet catches in 4Ra were also dominated by spring spawners in June. This was also seen in 1995 and appears to confirm the presence of a previously unreported spring-spawning area. Autumn spawners are more prevalent in deeper waters outside of St. George's Bay or north of Cape St. George in 4Rc as seen in the purse seine catches (McQuinn and Lefebvre 1995b). In the summer and fall (July to September), catches are mostly autumn spawners towards the north around the major autumn-spawning grounds (Table 3, Figures 6c,d,e) and are mixed in the southern regions (Table 4). In the late-fall purse seine fishery (October to December), catches are a mix of spring and autumn spawners, although again there is

a predominance of autumn spawners towards the north and spring spawners towards the south (Figures 6f,g,h).

Spring spawners have dominated the catch in every year since at least 1973 (Table 5), averaging 72% in numbers. This percentage increased to over 80% between 1988 and 1990 due to the active spring fishery in St. George's Bay, which exploited mainly spring spawners nearshore (Table 4). With the closure of St. George's Bay to commercial fishing in 1994, the percentage of spring spawners in the total catch has since decreased to between 50 and 60%.

Age Composition of the Catch

From the mid-1980's, the 1980 and 1982 spring-spawner year-classes supported the fishery (Table 5) and are still important contributors to the total catch (Figure 7). In 1991, the 1987 year-class recruited strongly to the purse seine fishery (Table 6). In 1995, the 1990 year-class recruited strongly to the overall spring-spawner catch (Figure 7) although more so in the north than on the southern spawning grounds. In 1996, the 1990 year-class dominated the purse seine catch, although the 1987 and older year-classes were still present. Biological samples supplied by the index fishermen revealed that the 1990 year-class was also present for the first time in the gillnet catches inside of St. George's Bay and Port-au-Port Bay in the spring of 1996. Recruiting year-classes are always seen 1-3 years later in the gillnet fishery than in the purse-seine fishery due to the different gear selectivities.

Since 1983, the 1979 autumn-spawning year-class has been the most important contributor to the fishery from this stock and is still a dominant year-class in 4Ra (Figures 6d,e). Since 1990, the 1986 year-class has strongly recruited to the autumn-spawner purse-seine catch (Table 6), but only became a significant contributor to the gillnet fishery in 1992 (McQuinn and Lefebvre 1996a). The 1988 and 1990 year-classes have also contributed significantly to the total autumn-spawner catch in recent years (Figure 8). These three year-classes have gradually increased in importance in the gillnet fishery since 1993.

Biological Condition

The overall condition factor, CF, of west coast of Newfoundland herring in the fall, as measured by the equation:

$$CF = \frac{W_S}{L_T^3} \cdot 10^7$$

where W_S is somatic weight (g) and L_T is total length (mm), showed a major decrease in 1993 and 1994 (Figure 9), corresponding with a general decrease in annual water temperatures noted for the northern Gulf of St. Lawrence. However, when put into the context of the last 27 years, average condition was much lower from 1973 to 1976. In 1995 and 1996, overall condition rebounded, although the recovery of the autumn spawners was somewhat less than for the spring spawners.

Abundance Indices

Acoustic Surveys

The 1995 acoustic survey estimated a minimum biomass of 84,000 t (38,000 t of spring spawners and 46,000 t of autumn spawners) with 64% of the herring biomass being surveyed in the two northern most strata (McQuinn and Lefebvre 1996b). The distribution of herring in the remaining strata was similar between 1993 and 1995, even though the survey was conducted three weeks earlier in 1995.

Index-Fisherman Logbook Data

Abundance indices were estimated for both spring and autumn spawners from detailed logbooks of daily catch and effort compiled by index gillnet fishermen since 1984 (Tables 7 and 8) and standardized using a multiplicative model (Gavaris 1980). The categorical variables for this model were year, month and fishing area, and were chosen to account for spatial and temporal variability (Tables 9 and 10). Prior to these analyses, catches were proportionately allocated to spring and autumn spawners using the percent spawning-stock composition as determined from the commercial samples (Table 4). Most of these fishermen set their nets in the vicinity of either the major spring-spawning sites in the St. George's Bay/Port-au-Port area (McQuinn and Lefebvre 1995a) or the autumn-spawning areas north of Point Riche.

The standardized spring-spawner catch rates for St. George's Bay and Port-au-Port indicated that the 1987 year-class was above average, but not sufficiently abundant in these southern bays to rebuild these local spawning components given the heavy fishing effort exercised on them in the early 1990s. In 1996 this catch-rate index increased for the first time since 1992, simultaneous with the recruitment of the 1990 year-class to this fishery (Figure 10, Table 11). The next year or two will indicate whether the recruitment of this year-class will be strong enough to rebuild these components.

The 1986 autumn-spawning cohort appeared quite strong in the index-fisherman catch rates in 1992 and seemed at that time to be well above the 10-year average (Figure 11, Table 11). However, it declined sharply from 1992 to 1994 and stabilised at a low level. Although this catch-rate index seemed to reflect the strong recruitment of the 1986 year-class, its sharp decline was unexpected given the low fishing effort on the autumn-spawning stock. In addition, the recent recruitment of the 1988 year-class has not been reflected in the index, which puts in doubt its usefulness as a measure of abundance. It is possible that this index is more a reflection of a change in availability, since it is known that autumn herring spawn farther offshore and are less available to inshore fixed gear than are the spring spawners.

Questionnaires

Comments collected from written questionnaires sent to all licensed inshore herring fishermen in 4R (Table 12) as well as from our index fishermen indicated some improvement in spring-spawning stocks in Port-au-Port Bay although it was felt that spawning activity had not yet improved significantly in St. George's Bay. There were also comments to the effect that the spring-spawning stock had improved in the Bay of Islands (Figure 12). The 1990 year-class,

which has been captured in the fall gillnet fishery since 1995, has started to spawn in these southern bays (Figure 6a,b). These observations are consistent with the catch rate data from index-fishermen in these areas (Figure 11).

North of Point Riche in 4Ra, the general opinion is that the abundance of herring is average to good especially in the summer and fall (Table 12), although along the Quebec shore comments indicated that the stock was in decline (Figure 11). Spawning in the fall was noted mainly south of Ferolle Point, and near Eddies Cove East.

Discussion

The present assessment indicates that the status of the west coast of Newfoundland herring stocks is generally healthy. Relatively young year-classes are in abundance among both the spring- and autumn-spawning herring in the purse seine fishery, as well as in the research surveys, and a high proportion of very old (16-17 years) fish still appear in the catch. The fall 1995 acoustic abundance survey indicated a minimum total stock biomass of approximately 84,000 t in October-November of 1995, with 38,000 t of spring-spawning (45 %) and 46,000 t of autumn spawners (55 %).

Spring Spawners

The 1990 spring-spawning year-class, which has been an important component of the purse seine catch since 1994, has now recruited to the gillnet fishery, including the southern spawning areas. The spring-spawner catch rates increased between 1995 and 1996, suggesting that the mature biomass in the southern spawning grounds had improved, primarily due to the recruitment of the 1990 year-class. Comments received from index fishermen and from the written questionnaires suggest some improvement in abundance over 1995 in Port-au-Port Bay, although with limited improvement in St. George's Bay. Continued improvement is expected as the 1990 year-class becomes fully recruited to the gillnet fishery. In addition, older year-classes (1980, 1982 and 1987) are still present in both the purse seine and gillnet catches, indicating a relatively low overall fishing mortality.

Autumn Spawners

The autumn-spawning stock has historically received less fishing effort than the spring spawners (less than 28% of the total catch) since it occurs more in the northern areas farther from the principle landing ports. This has resulted in a wide age distribution in this stock, where in some areas the 1979 year-class is still dominant. The sharp decline in the logbook catch-rate data in 1992 is in contradiction with other indices which show this stock to be in relatively good condition: (1) the fall acoustic survey estimate of at least 46,000 t, (2) the light exploitation of this stock over the past decade, and (3) responses to a written questionnaire indicating that the situation with this spawning component along the Newfoundland shore north of Point Riche is relatively good. It is quite possible that the index-fisherman catch-rate series has become less reliable due to (1) a decrease in participation in the program (three to four logbooks annually

since 1992) and (2) the decrease in availability to inshore gillnets as the herring have moved farther offshore (McQuinn and Lefebvre 1994).

Prognoses

The present analyses of the available commercial and research data has allowed us to conclude that in general, fishing mortality on these stocks over the past 20 years has not been excessive and that status quo harvest levels would not likely exceed $F_{0.1}$. However, the concentration of fishing in the early 1990's in the southern bays did harvest disproportionately more spring spawners from this local component and resulted in a sharp decrease in its abundance. The closure of these bays in 1995 had the desired affect of concentrating fishing on the autumn spawners outside of St. George's Bay, of decreasing the quantity of spring spawners in the total catch and of allowing these fish to spawn undisturbed.

St. George's Bay/Port-au-Port Bay

The strong recruitment of the 1990 year-class to the purse seine fishery since 1994, and its appearance in the spring gillnet fishery in 1996 suggests that there is no longer a biological rationale for the continued exclusion of commercial fishing from St. George's and Port-au-Port Bays. However, the lessons learned from the reduction in abundance of spawning herring in St. George's Bay and Port-au-Port Bay underline the importance of protecting local spawning components from disproportionately high fishing effort. The conservation of each individual local spawning component ensures the continuation of the local fisheries dependent upon them and maintains the reproductive potential of the entire stock. It is recommended that the reopening of the closed areas proceed with caution, with no concentrated fishing on or near the spawning grounds. For this reason, areas of known spawning activity should remained closed to intensive fishing.

The fishery in St. George's Bay must continue to be watched closely. Although it is expected that the 1990 year-class will bolster these local components, it is nonetheless recommended that a harvest limit be imposed for St. George's Bay and Port-au-Port Bay to allow fishing to proceed in a prudent manner, and that the distribution and composition of catches from within these bays be closely monitored. The continuation and enhancement of the index-fisherman program in this area is essential for the monitoring of spawning activity and as a local abundance index.

The widespread appearance of the 1990 year-class in both the spring and autumn stocks in 1996, as well as the observation of an abundance of 2 year-old herring in the Bay of Islands in the late fall (Figure 6g,h) are encouraging signs for the medium term outlook of these stocks. It is therefore concluded that the current TAC of 22,000 t of spring- and autumn-spawning herring could be maintained without exerting excessive fishing pressure on these stocks. However, to avoid a repetition of intensive fishing on any one local spawning component, it is recommended that fishing effort be spread out along the coast and throughout the year as much as possible.

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Table 1. Herring catches (t) by gear type and fishing area and total allowable catches from NAFO Division 4R from 1966 to 1996.

YEAR	4Rd					4Rc					4Rb					4Ra					COMBINED					TAC
	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	
1966	0		216	0	216	0		103	0	103	5491		39	0	5530	0		45	0	45	5491		403	0	5894	
1967	0		215	0	215	0		66	0	66	5464		76	0	5540	0		40	0	40	5464		397	0	5861	
1968	0		156	789	945	0		59	0	59	3776		67	136	3979	0		11	0	11	3776		293	925	4994	
1969	241		36	6	283	0		46	0	46	2344		201	4	2549	0		68	1	69	2585		351	11	2947	
1970	28		51	3	82	12		15	17	44	2939		534	4	3477	0		407	92	499	2979		1007	116	4102	
1971	3287		543	427	4257	2239		185	24	2448	725		338	21	1084	356		1598	11	1965	6607		2664	483	9754	
1972	4743		178	866	5787	727		135	64	926	1330		214	0	1544	0		3628	146	3774	6800		4155	1076	12031	
1973	12112		429	0	12541	2740		122	0	2862	1763		305	2	2070	3453		5760	15	9228	20068		6616	17	26701	
1974	2465		159	0	2624	756		101	4	861	439		479	47	965	1071		1972	5	3048	4731		2711	56	7498	
1975	3221		116	3	3340	0		112	16	128	0		240	26	266	0		1764	22	1786	3221		2232	67	5520	
1976	6067		499	3	6569	1956		111	2	2069	0		226	20	246	184		2143	140	2467	8207		2979	165	11351	
1977	5289		272	7	5568	2009		193	3	2205	0		158	31	189	2155		2028	183	4366	9453		2651	224	12328	12000
1978	6252		522	33	6807	1037		931	16	1984	0		288	81	369	1834		3795	22	5651	9123		5536	152	14811	12500
1979	4387		1642	3	6032	2774		2267	2	5043	2829		1048	121	3998	0		3258	7	3265	9990		8215	133	18338	12500
1980	3499		1558	41	5098	3703		3224	17	6944	2002		879	88	2969	428		3810	5	4243	9632		9471	151	19254	18000
1981	2269		1368	2	3639	3277		1622	0	4899	2037		913	140	3090	342		1600	27	1969	7925		5503	169	13597	16000
1982	0		1463	3	1466	5575		1572	11	7158	3973		519	58	4550	0		1695	1	1696	9548		5249	73	14870 [2]	10000
1983	0		1410	2	1412	3269		873	46	4188	3223		226	108	3557	787		1438	34	2259	7279		3947	190	11416 [2]	10000
1984	0		1006	1	1007	3023		902	0	3925	4166		554	2	4722	15		790	4	809	7206		3252	7	10465 [2]	10000
1985	1720		398	0	2118	1733		164	0	1897	9718		348	4	10070	0		295	6	301	13171		1205	10	14386 [2]	10000
1986	1854		273	0	2127	1586		1069	0	2655	15830		468	0	16298	0		337	0	337	19270		2147	0	21417 [2]	17000
1987	222		550	0	772	3183		1137	0	4320	10164		327	5	10496	164		829	0	993	13733		2843	5	16581	30600
1988	2019		435	0	2454	13197		592	0	13789	1093		256	0	1349	44		509	0	553	16353		1792	0	18145	30600
1989	9111		177	0	9288	6589		444	0	7033	947		69	0	1016	13		337	0	350	16660		1027	0	17687	37000
1990	5050		152	0	5202	7247		187	0	7434	4004		174	13	4191	0		323	134	457	16301		836	147	17284	35000
1991	16287		133	0	16420	2318		175	0	2493	6838		103	7	6948	151		368	57	576	25594		779	63	26437	35000
1992	7169	1279	27	1	8476	1271	82	38	0	1391	3954	146	47	1	4148	0	347	440	115	902	12394	1853	552	117	14915	35000
1993	8634	2333	55	1	11023	740	276	9	5	1029	1899	299	20	0	2218	362	332	55	103	852	11634	3240	139	108	15121	35000
1994	1472	1010	117	0	2599	2026	951	75	0	3053	4063	1487	161	0	5711	72	406	394	145	1017	7634	3854	747	146	12380	35000
1995	2755	201	163	14	3133	5457	1680	179	5	7321	2138	930	101	104	3273	464	580	1215	24	2283	10814	3392	1658	148	16012	22000
1996	600	450	65	0	1115	6705	1305	84	6	8100	1896	798	143	27	2864	226	252	2035	71	2584	9427	2805	2326	104	14662 [1]	22000

* Includes shrimp trawl, bar seine, cod trap, midwater trawl and otter trawl.

[1] Preliminary

[2] Purse seine landings adjusted according to industry records.

Table 2a. Herring landings (t) by large purse seiners (>65') in NAFO division 4R by unit area and month from 1988 to 1996.

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	4Ra							22	22					44
	4Rb									71	312	437	273	1093
	4Rc				639	5342	70		6		990	1985	4165	13197
	4Rd				1308	711								2019
	Total				1947	6053	70	22	28	71	1302	2422	4438	16353
1989	4Ra								13					13
	4Rb				33						81	347	486	947
	4Rc				35		51		6	514	776	3080	2127	6589
	4Rd				379	8587	145							9111
	Total				447	8587	196		19	514	857	3427	2613	16660
1990	4Ra													
	4Rb										641	2266	1097	4004
	4Rc					6398	394	358	27	17		53		7247
	4Rd				6	4751	281					12		5050
	Total				6	11149	675	358	27	17	641	2331	1097	16301
1991	4Ra							77	62	13				151
	4Rb						78	139	18	61	502	4407	1634	6838
	4Rc					718	61	234		121	143	205	837	2318
	4Rd				6700	8283	236						1069	16287
	Total				6700	9001	374	449	79	194	645	4612	3540	25594
1992	4Ra													
	4Rb										87	3867		3954
	4Rc					8	689				56	518		1271
	4Rd					6860	185				2	122		7169
	Total					6868	874				145	4507		12394
1993	4Ra											362		362
	4Rb									1	780	1118		1899
	4Rc									1	700	39		740
	4Rd				1253	7347						34		8310
	Total				1253	7347				1	1480	1553		11634
1994	4Ra											72		72
	4Rb								640	1031	679	1714		4063
	4Rc					140	153	15	398	391	930			2026
	4Rd					817	31			13	612			1472
	Total					957	184	15	1037	1434	2220	1786		7634
1995	4Ra											464		464
	4Rb									333	328	297	1181	2138
	4Rc					570	2445			514	1169	321	439	5457
	4Rd					1693	69			181	736	77		2755
	Total					2263	2513			1028	2233	1160	1619	10815
1996	4Ra								226					226
	4Rb									253	193	1449		1896
	4Rc					323	546			278	1897	1829	1833	6705
	4Rd						27			75	129	368		600
	Total					323	574	0	226	606	2219	3646	1833	9427

Table 2b. Herring landings (t) by small purse seiners (< 65') in NAFO division 4R by unit area and month from 1992 to 1996.

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1992	4Ra						86	259	2					347
	4Rb						18					127		146
	4Rc					15	34			19	1	14		82
	4Rd					1081	79					118	1	1279
	Total					1096	216	259	2	19	1	259	1	1853
1993	4Ra					11	127	78	51	4		61		332
	4Rb		15						57	61	44	123		299
	4Rc				2	143	29		9	1	63	28		276
	4Rd				84	1774					78	396		2333
	Total		15		86	1929	156	78	116	67	186	608		3240
1994	4Ra						87	18	13	20		267		406
	4Rb							49	123	941	258	116		1487
	4Rc					159	320	2	73	110	225	62		951
	4Rd					597	51				362			1010
	Total					756	459	69	209	1071	845	445		3854
1995	4Ra							74	46	8	21	383	48	580
	4Rb						391	1	38	308	147	45		930
	4Rc					126	317	44	428	406	263	4	94	1680
	4Rd						18				184			201
	Total					126	726	119	513	722	614	431	141	3392
1996	4Ra						170	13		21	31	17		252
	4Rb					3	263	2		56	342	87	45	798
	4Rc					241	62			220	550	121	111	1305
	4Rd										411	39		450
	Total					244	495	15	0	297	1334	264	156	2805

Table 2c. Herring landings (t) by gillnets in NAFO division 4R by unit area and month from 1988 to 1996.

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	4Ra					14			18	5	208	225	36	506
	4Rb				11	15	23	7	4	2	60	114	21	257
	4Rc				34	61	227	186	10	4	7	18	45	592
	4Rd				108	113	43	142	8	8	11	1		434
	Total				153	203	293	335	40	19	286	358	104	1791
1989	4Ra					4	34	13			4	182	100	337
	4Rb		1	2	8	16	24	8	2	1	7			69
	4Rc				10	213	101	108		11		1		444
	4Rd				2	107	36	19	7	5		1		177
	Total		1	2	20	340	195	148	9	17	11	184	100	1027
1990	4Ra					4	9	3	13	49	28	216		323
	4Rb				10	13	20	9	3	1	1	117		174
	4Rc					42	89	46	3	2	5			187
	4Rd				1	34	66	40	9	2	1			152
	Total				11	93	184	98	28	54	35	333		836
1991	4Ra					6	49	178	43	24	24	45		368
	4Rb					13	27	2		1	12	47		103
	4Rc						104	40	6	16	9			175
	4Rd				30	40	23	10	12	12	6	4		133
	Total				30	58	203	230	59	53	51	96		779
1992	4Ra					9	15	179	34	11	108	84		440
	4Rb			2	3	15	20	1			3	3		47
	4Rc					22	2	2	6	1	2	3		38
	4Rd					15	3	1	5	1	1	2	1	27
	Total			2	3	61	39	183	45	13	115	91	1	552
1993	4Ra						5	47	1	1				55
	4Rb						10	2	1		4	4		20
	4Rc					2		1	1	3	3			9
	4Rd				6	38	1	1	2	2	5	1		55
	Total				6	40	16	51	5	5	11	5		139
1994	4Ra							232	51	107	5			394
	4Rb						3	5		116	26	10		161
	4Rc					21	42	7	2	4				75
	4Rd					34	59	16	3	6				117
	Total					55	104	260	56	233	31	10		747
1995	4Ra					1	10	537	359	116	41	129	23	1215
	4Rb				3	4	6	21	9	6	21	10	21	101
	4Rc			1	2	46	69	9	24	20	4	3		179
	4Rd					62	61	11	7	21	1			163
	Total			1	5	113	146	578	399	163	67	142	44	1658
1996	4Ra						253	275	121	442	896	48		2035
	4Rb					2	3	9		106	24			143
	4Rc					37	14		1	17	16			84
	4Rd						1			58	7			65
	Total					39	269	284	122	543	943	48		2326

Table 3. Proportion (%) of spring-spawning herring in the gillnet catch by month and fishing area, NAFO division 4R from 1974 to 1996.

SPAWNING GROUP	FISHING AREA																							
	4Rd			4Rc						4Rb							4Ra							
SPRING	APR	MAY	JUN	APR	MAY	JUN	JUL	SEP	OCT	MAY	JUN	JUL	SEP	OCT	NOV	DEC	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1974										99.0					86.5				14.3			50.0		
1975		90.0								55.3	12.0													
1976		100.0								96.0								5.3				76.7		
1977										83.3	18.0				86.0		66.0	32.2	8.0	25.7	56.6	78.0		
1978		99.0							85.7	98.0							52.0	33.6				78.9		
1979	84.0			92.8					95.0					84.0				36.7	11.7	44.0	56.0			
1980	96.4			91.1					100.0					81.8		63.3	55.6	34.1	3.0	42.9	72.0	66.0		
1981				95.8					82.4	91.0							37.0	24.9	0.7			43.8		
1982					97.2									64.9				2.7						
1983		95.7										60.0	46.1	41.8				39.6	1.4	46.3	56.9	56.3	68.2	
1984		94.1			78.5			84.0					60.2		44.9				8.6	27.9	63.0	36.0	52.7	
1985		97.7			86.5	90.0												80.0	9.5	15.7		28.0		
1986	84.4	98.4		50.0	83.7			66.0	80.0						54.4				16.8	10.1	32.0	44.1	27.1	
1987	92.0	99.4		52.0	84.7	88.6							52.2						14.2	26.0	49.5	37.5		
1988	98.0	99.6	96.0	73.5	78.3	81.4	76.0						68.1				28.0	11.8	27.0	41.3	52.8	42.0		
1989		99.0	91.1	86.0	85.3	79.6								71.0	56.7				22.3	11.6	23.3	44.0	40.0	
1990		96.9	99.3		92.0	88.5	34.5								44.0				15.5	17.8	10.8	18.0	32.5	
1991		95.9	96.0		88.8	59.2							32.0	44.0	70.0				4.5	27.0	38.1	50.0	43.4	
1992		93.2	76.0		74.8	70.4	52.0											26.0	10.0	8.3	1.0	10.2		
1993		98.0			78.7	89.0												86.0	4.0	4.0	1.7			
1994		97.5	99.3		94.0	88.8	2.0												7.5	1.5	11.6			
1995		95.1	90.0		91.2	83.0	67.3					48.0						72.0	11.6	2.7	9.1	42.0	45.3	34.0
1996	97.0	97.7	95.9		94.2	88.4					68.0		3.0	32.0				46.0	2.0	1.8	1.9	23.5	30.0	

Table 4. Proportion (%) of spring-spawning herring in the purse seine catch by month and fishing area, NAFO Division 4R from 1974 to 1996.

YEAR	FISHING AREA														
	4Rd					4Rc									
	APR	MAY	SEPT	OCT	NOV	JAN	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1974	68.3	39.1													
1975	98.0	84.7													
1976	90.4	97.6						52.3							
1977	95.4	99.0						32.4							
1978	82.4						81.9								
1979	86.2						43.2	26.0							
1980	95.2						98.0								73.4
1981	96.4	92.0					97.3								
1982							99.8	98.0				65.0			
1983							61.0	54.5					73.8		
1984						76.4	43.9								
1985		92.0						66.0	49.7				82.6		
1986	77.0	100.0						93.6		78.0					
1987		97.0					100.0	93.0	100.0			65.3	84.7		
1988	83.6	99.5						34.0	100.0						
1989	91.3							34.0				79.5	66.9		
1990		89.8								78.0			88.0		
1991		71.6								72.0		48.0	66.0		80.0
1992		94.7	72.7				100.0	100.0			28.6		68.2		
1993	90.0	85.0											67.8		
1994		94.5		40.5				93.9	94.5		29.3	54.2	47.4	48.0	
1995		44.0	52.0	48.7				98.0	99.3		48.7	59.0	64.0	76.0	33.0
1996				68.0	72.0			100.0	98.8			58.1		50.0	37.2

	4Rb								4Ra						
	APR	MAY	JUN	AUG	SEP	OCT	NOV	DEC	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1974								92.6							
1975															
1976															87.7
1977													47.3	89.3	
1978														85.8	84.4
1979							93.3							91.6	86.7
1980							88.2								
1981						87.3	63.5	55.7							
1982						78.8	77.7								
1983							79.8	68.9						74.7	62.7
1984	40.9					76.9	64.5	60.5						62.0	
1985				23.8		71.0	70.0	67.7							
1986						77.3	74.8	71.0							
1987				0.0		74.5	76.9	72.1						28.0	
1988	37.5				62.0	41.3	65.8	72.1		28.0	2.0				
1989						68.5	70.1	70.1							
1990						74.0	55.3	66.0							
1991						56.3	65.3	63.4							
1992			47.7			32.0	49.9								
1993		74.0				72.7	56.6					0.0		22.0	
1994				13.3	36.4	33.2	51.3							39.0	
1995			98.0		2.0	57.6	39.0	36.0						33.3	34.0
1996					18.0		40.0		99.0		0.0		35.0		

Table 5. Spring- and autumn-spawner catch at age ($x10^3$) and proportion of spring spawners in NAFO division 4R herring landings from 1973 to 1996 (all gears)

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0	0	0	0	45	0	0	3	13	0	4	39	48	265	323	183	0	0	0	0	0	0	0	0
2	1833	141	57	484	10	0	167	300	40	594	34	198	362	323	455	734	305	100	457	90	79	14	13	1323
3	435	261	996	680	534	47	25	854	417	2374	2965	433	4587	2348	329	519	574	2056	2213	1243	1589	296	264	245
4	1063	130	420	846	541	1987	214	106	2114	693	3562	7773	787	13762	2781	417	783	610	10053	1708	3800	2522	3460	1174
5	27872	371	100	201	409	207	10828	355	129	2452	1131	3809	21642	3349	15257	2400	461	412	1311	8377	3411	3040	6573	3826
6	2570	9445	1063	350	304	679	617	13872	354	421	1091	595	3993	28781	3507	14830	3036	983	805	997	6776	3689	6243	7515
7	3222	318	8431	2802	348	241	1075	407	8872	2153	293	814	445	5241	12952	4004	18705	5002	3063	998	1504	3379	6417	4000
8	3232	851	317	15567	4362	2162	547	1344	188	8488	713	209	381	465	1736	14606	3072	16049	6967	2783	2110	1616	2330	563
9	2598	774	336	759	15959	8208	2772	247	515	704	2990	672	255	167	182	2734	10910	3782	21372	2168	2713	1620	2340	3014
10	4789	490	244	3136	1694	15260	7404	1427	283	950	798	755	380	260	37	480	779	6472	2356	11882	2798	1775	2041	438
11+	5696	2175	665	3588	6003	5062	14032	20574	13181	12863	7975	4226	1764	1661	806	2123	1380	2130	6558	4064	8816	2080	359	1550
1+	53310	14955	12629	28413	30210	33851	37681	39488	26106	29892	21556	19523	34645	56621	38365	43030	39985	37594	55156	34310	33597	20032	30038	23648

AUTUMN SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	1	0
2	0	0	0	0	0	0	0	15	0	101	15	0	15	35	0	484	43	38	46	0	21	0	31	0
3	1798	20	19	48	3	10	7	181	33	567	83	55	235	426	156	207	599	463	931	337	210	52	108	1905
4	1180	393	40	272	169	27	116	136	524	1824	2330	668	1340	1431	487	511	539	1391	1312	1416	676	866	1942	1285
5	1114	530	865	290	134	545	345	86	245	956	1356	6259	1907	2671	1354	481	923	387	5828	1446	1955	2519	4723	2525
6	2626	325	925	422	404	393	2689	176	90	509	1309	1147	9878	2292	2009	1240	807	312	731	1235	1011	3773	4482	8253
7	1527	592	107	561	721	1108	520	1729	295	140	506	908	902	8421	1728	1740	749	468	1487	776	1651	3020	3763	2119
8	2631	258	157	325	405	1689	1287	250	1234	377	159	220	622	794	5927	1667	828	323	850	542	589	2399	1960	3643
9	3830	308	147	253	342	503	1847	675	153	972	467	146	115	384	474	4165	961	1027	611	777	918	1609	1811	666
10	8265	313	218	88	293	341	468	308	124	315	618	268	36	66	163	705	2873	442	2079	389	884	1176	1158	1766
11+	17653	5610	3371	4818	6646	6051	6286	5243	3389	2609	2824	3091	468	227	196	777	983	4223	6890	3925	4592	3957	1807	2817
1+	40626	8348	5848	7076	9116	10868	13564	8799	6067	8371	9667	12762	15333	16745	12494	11977	9305	9072	20748	10873	12486	19371	21785	24980

TOTAL (SPRING AND AUTUMN)

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
TOTAL	93937	23303	18477	35489	39326	44520	51245	48288	32173	38062	31223	32286	49978	73366	50859	53475	49292	46666	75901	45183	46084	39403	51823	48628
% SS	56.8	64.2	68.4	80.1	76.8	76.0	73.5	81.8	81.1	78.0	69.0	60.5	69.3	77.2	75.4	80.5	81.1	80.6	72.7	75.9	72.9	50.8	58.0	48.6

Table 6. Age composition (%) and mean age* of spring- and autumn-spawners in NAFO division 4R herring landings from 1973 to 1996 (dominant year-classes have been underlined)

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.1	0.5	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	3.4	0.9	0.5	1.7	0.0	0.0	0.4	0.8	0.2	2.0	0.2	1.0	1.0	0.6	1.2	1.7	0.8	0.3	0.8	0.3	0.2	0.1	0.0	5.6
3	0.8	1.7	7.9	2.4	1.8	0.1	0.1	2.2	1.6	8.0	13.8	2.2	13.2	4.1	0.9	1.2	1.4	5.5	4.0	3.6	4.7	1.5	0.9	1.0
4	2.0	0.9	3.3	3.0	1.8	5.9	0.6	0.3	8.1	2.3	16.5	39.8	2.3	24.3	7.2	1.0	1.9	1.6	18.2	8.0	11.3	12.6	11.5	5.0
5	52.3	2.5	0.8	0.7	1.4	0.6	28.7	0.9	0.5	8.3	5.2	19.5	62.5	5.9	39.8	5.6	1.2	1.1	2.4	24.4	10.2	15.2	21.9	16.2
6	4.8	63.2	8.4	1.2	1.0	2.0	1.6	35.1	1.4	1.4	5.1	3.0	11.5	50.8	9.1	34.5	7.6	2.8	1.5	2.9	20.2	18.4	20.8	31.8
7	6.0	2.1	66.8	9.9	1.2	0.7	2.9	1.0	34.0	7.3	1.4	4.2	1.3	9.3	33.8	9.3	46.8	13.3	5.6	2.9	4.5	16.9	21.4	16.9
8	6.1	5.7	2.5	54.6	14.4	6.4	1.5	3.4	0.7	21.9	3.3	1.1	1.1	0.8	4.5	33.9	7.7	42.7	12.6	8.1	6.3	8.1	7.8	2.4
9	4.9	5.2	2.7	2.7	52.8	24.2	7.4	0.6	2.0	2.4	13.9	3.4	0.7	0.3	0.5	6.4	27.3	10.1	38.7	6.3	8.1	8.1	7.8	12.7
10	9.0	3.3	1.9	11.0	5.6	45.1	19.6	3.6	1.1	3.2	3.7	3.9	1.1	0.5	0.1	1.1	1.9	17.2	4.3	34.6	8.3	8.9	6.6	1.9
11+	10.7	14.5	5.3	12.6	19.9	15.0	37.2	52.1	50.5	43.3	37.0	21.6	5.1	2.9	2.1	4.9	3.5	5.7	11.9	11.8	26.2	10.4	1.2	6.6

MEAN AGE* OF INDIVIDUALS IN CATCH

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE	6.5	7.0	6.8	8.1	9.0	9.3	8.6	8.7	8.8	8.4	7.7	6.3	5.3	5.6	5.9	7.0	7.6	8.0	7.7	7.9	7.6	7.0	6.5	6.5

AUTUMN SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.2	0.2	0.0	0.1	0.2	0.0	4.6	0.5	0.4	0.2	0.0	0.2	0.0	0.1	0.0
3	4.4	0.2	0.3	0.7	0.0	0.1	0.1	2.1	0.5	6.8	0.9	0.4	1.5	2.5	1.3	1.8	6.4	5.1	4.5	3.1	1.7	0.3	0.5	7.6
4	2.9	4.7	0.7	3.8	1.9	0.2	0.9	1.5	8.6	21.6	24.1	5.2	8.7	8.5	3.9	5.0	5.8	15.3	6.3	13.3	5.4	4.5	8.9	5.1
5	2.7	6.4	14.8	4.1	1.5	5.1	2.5	1.0	4.0	11.4	14.0	49.0	12.4	15.9	10.8	4.7	9.9	4.3	28.1	13.3	15.7	13.0	21.7	10.1
6	6.5	3.9	15.8	6.0	4.4	3.7	19.8	2.0	1.5	6.1	13.5	9.0	63.1	13.7	16.1	9.8	8.7	3.4	3.5	11.4	8.1	19.5	20.6	33.0
7	3.8	7.1	1.8	7.9	7.9	10.4	3.8	19.7	4.9	1.7	5.2	7.1	5.9	50.3	13.8	12.1	8.0	5.1	7.1	7.1	13.2	15.6	17.3	8.5
8	6.5	3.1	2.7	4.6	4.4	15.8	9.5	2.8	20.3	4.5	1.6	1.7	4.1	4.7	47.4	14.4	8.9	3.6	4.1	9.0	4.6	12.4	9.0	14.6
9	9.4	3.7	2.5	3.6	3.8	4.7	13.6	7.7	2.5	11.6	4.8	1.1	0.7	2.3	3.8	36.4	10.3	11.3	2.9	7.1	7.4	8.3	8.3	2.7
10	20.3	3.8	3.7	1.3	3.2	3.2	3.5	3.5	2.0	3.8	6.4	2.1	0.2	0.4	1.3	4.8	30.9	4.9	10.0	3.6	7.1	6.1	5.3	7.1
11+	43.5	67.2	57.6	68.1	72.9	56.7	46.3	59.6	55.5	31.2	29.2	24.2	3.1	1.4	1.6	6.4	10.6	46.5	33.2	36.1	36.8	20.4	8.3	11.3

MEAN AGE* OF INDIVIDUALS IN CATCH

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE	9.2	9.6	9.0	9.6	10.0	9.5	9.0	9.5	9.2	7.4	7.3	6.8	6.0	6.3	7.1	7.7	7.9	8.5	7.7	7.8	8.2	7.7	6.8	6.9

* assuming agers 11+ to be 11

Table 7. Frequency of observations of index-fisherman catch and effort data by month, fishing area and year for spring-spawning herring in NAFO unit areas 4Rd and 4Rc (St. Georges Bay/Port-au-Port Bay).

MONTH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
4	106	5.7	106	5.7
5	1112	59.3	1218	65.0
6	633	33.8	1851	98.8
7	23	1.2	1874	100.0

FISHING AREA	Frequency	Percent	Cumulative Frequency	Cumulative Percent
FISCHELL	254	13.6	254	13.6
SANDY POINT	440	23.5	694	37.0
ST-GEORGES	117	6.2	811	43.3
BARACHOIS BROOK	132	7.0	943	50.3
LOURDES	283	15.1	1226	65.4
BLACK DUCK BROOK	307	16.4	1533	81.8
LONG PT. (BAY)	341	18.2	1874	100.0

YEAR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
85	103	5.5	103	5.5
86	123	6.6	226	12.1
87	165	8.8	391	20.9
88	160	8.5	551	29.4
89	173	9.2	724	38.6
90	128	6.8	852	45.5
91	132	7.0	984	52.5
92	176	9.4	1160	61.9
93	169	9.0	1329	70.9
94	171	9.1	1500	80.0
95	217	11.6	1717	91.6
96	157	8.4	1874	100.0

Table 8. Frequency of observations of index-fisherman catch and effort data by month, fishing area and year for autumn-spawning herring in NAFO unit areas 4Ra, 4Rb and 4Rc.

MONTH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
4	21	0.8	21	0.8
5	481	19.4	502	20.2
6	411	16.5	913	36.7
7	244	9.8	1157	46.6
8	886	35.7	2043	82.2
9	388	15.6	2431	97.8
10	44	1.8	2475	99.6
11	10	0.4	2485	100.0

FISHING AREA	Frequency	Percent	Cumulative Frequency	Cumulative Percent
LOURDES	283	11.4	283	11.4
BLUE BEACH	236	9.5	519	20.9
LONG PT. (BAY)	412	16.6	931	37.5
CASTOR RIVER	43	1.7	974	39.2
FERROLE POINT	758	30.5	1732	69.7
WHALE ISLAND	12	0.5	1744	70.2
EDDIES COVE E	741	29.8	2485	100.0

YEAR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
84	96	3.9	96	3.9
85	147	5.9	243	9.8
86	158	6.4	401	16.1
87	207	8.3	608	24.5
88	279	11.2	887	35.7
89	229	9.2	1116	44.9
90	209	8.4	1325	53.3
91	167	6.7	1492	60.0
92	171	6.9	1663	66.9
93	207	8.3	1870	75.3
94	197	7.9	2067	83.2
95	224	9.0	2291	92.2
96	194	7.8	2485	100.0

Table 9. Analysis of variance and regression coefficients for the 1984 to 1996 spring-spawning 4R herring catch rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	20	1285.796920	64.289846	30.54	0.0001
Error	1853	3900.159659	2.104781		
Corrected Total	1873	5185.956579			

R-Square	C.V.	Root MSE	CATRATE Mean
0.247938	-26.58424	1.450786	-5.457318

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	3	409.2112753	136.4037584	64.81	0.0001
FISH	6	381.4516407	63.5752735	30.21	0.0001
YEAR	11	188.3434550	17.1221323	8.13	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-6.669867101 B	-18.08	0.0001	0.36885233
MONTH	4	2.187048368 B	6.29	0.0001	0.34780617
	5	2.624232968 B	8.39	0.0001	0.31280809
	6	1.675696816 B	5.39	0.0001	0.31100663
	7	0.000000000 B	.	.	.
FISH	BARACHOIS BROOK	-1.359192198 B	-6.80	0.0001	0.19973916
	BLACK DUCK BROOK	-1.576314044 B	-9.07	0.0001	0.17388568
	FISCHELL	-0.817470873 B	-4.38	0.0001	0.18642845
	LONG PT. (BAY)	-1.178014507 B	-6.70	0.0001	0.17593832
	LOURDES	-1.929141029 B	-10.93	0.0001	0.17645904
	SANDY POINT	-1.005573411 B	-5.97	0.0001	0.16855304
	ST-GEORGES	0.000000000 B	.	.	.
YEAR	85	0.173998097 B	0.90	0.3671	0.19285594
	86	0.538805135 B	3.02	0.0026	0.17851708
	87	0.416170141 B	2.36	0.0182	0.17609954
	88	0.063160889 B	0.38	0.7047	0.16665205
	89	0.294357926 B	1.81	0.0708	0.16281431
	90	0.538939034 B	3.03	0.0025	0.17778434
	91	0.435303394 B	2.51	0.0120	0.17314146
	92	0.501633678 B	3.08	0.0021	0.16307686
	93	0.169053298 B	1.04	0.2981	0.16243682
	94	-0.175181753 B	-1.07	0.2835	0.16330578
	95	-0.481704455 B	-3.14	0.0017	0.15333120
	96	0.000000000 B	.	.	.

Table 10. Analysis of variance and regression coefficients for the 1984 to 1995 autumn-spawning 4R herring catch rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	25	2691.056598	107.642264	62.32	0.0001
Error	2459	4247.462652	1.727313		
Corrected Total	2484	6938.519250			

R-Square	C.V.	Root MSE	CATRATE Mean
0.387843	-20.16682	1.314273	-6.517007

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	7	252.2589448	36.0369921	20.86	0.0001
FISH	6	536.8515350	89.4752558	51.80	0.0001
YEAR	12	559.3317790	46.6109816	26.98	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-15.51279795 B	-26.40	0.0001	0.58757968
MONTH	4	4.65073147 B	7.65	0.0001	0.60801808
	5	4.12659674 B	7.70	0.0001	0.53575977
	6	4.09158719 B	7.64	0.0001	0.53561390
	7	4.79093801 B	11.09	0.0001	0.43193540
	8	4.84451473 B	11.36	0.0001	0.42628701
	9	4.67502805 B	10.86	0.0001	0.43041527
	10	4.22906852 B	8.97	0.0001	0.47134502
	11	0.00000000 B	.	.	.
FISH	BLUE BEACH	4.42765544 B	8.57	0.0001	0.51680914
	CASTOR RIVER	3.12815808 B	7.12	0.0001	0.43944348
	EDDIES COVE E	4.76661288 B	12.21	0.0001	0.39041274
	FERROLE POINT	4.82879589 B	12.33	0.0001	0.39162475
	LONG PT. (BAY)	3.65698279 B	7.11	0.0001	0.51404744
	LOURDES	3.33381485 B	6.50	0.0001	0.51290610
	WHALE ISLAND	0.00000000 B	.	.	.
YEAR	84	-0.49609237 B	-2.94	0.0033	0.16850113
	85	0.90668178 B	5.91	0.0001	0.15347396
	86	0.64851853 B	4.41	0.0001	0.14704278
	87	0.39307478 B	2.86	0.0043	0.13765615
	88	0.32282420 B	2.48	0.0131	0.12995303
	89	0.11813304 B	0.88	0.3804	0.13466069
	90	-0.75000688 B	-5.50	0.0001	0.13646450
	91	0.12039799 B	0.82	0.4100	0.14610906
	92	0.84602542 B	5.84	0.0001	0.14489149
	93	0.44257210 B	3.19	0.0015	0.13894294
	94	-0.39311102 B	-2.81	0.0050	0.13996047
	95	-0.45337204 B	-3.42	0.0006	0.13265304
	96	0.00000000 B	.	.	.

Table 11. Predicted mean catch rate estimates for spring- and autumn-spawning herring in NAFO Division 4R.

	SPRING SPAWNERS		AUTUMN SPAWNERS	
YEAR	CATCH RATE	STANDARD ERROR	CATCH RATE	STANDARD ERROR
84			0.46992	0.06653
85	0.92616	0.15382	1.91557	0.23664
86	1.33650	0.20606	1.48135	0.16954
87	1.18228	0.18210	1.14892	0.11776
88	0.83202	0.11901	1.07151	0.10469
89	1.04878	0.14765	0.87231	0.09346
90	1.33518	0.21513	0.36610	0.03953
91	1.20529	0.18457	0.87299	0.10475
92	1.28930	0.18856	1.80349	0.21754
93	0.92520	0.13070	1.20652	0.13018
94	0.65538	0.09506	0.52309	0.05670
95	0.48320	0.06418	0.49299	0.04877
96	0.78071	0.11430	0.77524	0.08185

Table 12. Number of spontaneous comments received from questionnaires sent to inshore herring fishermen along the west coast of Newfoundland in 1996.

COMMENTS	4Rd	4Rc	4Rb	4Ra	TOTAL
Herring abundant	1	5	6	8	20
during fall	1	2	3	5	11
during summer			3	1	4
Herring stock in decline	8	1	3	10	22
during spring			6		6
during fall			3	1	4
Complaints against seiners:					
excessive catches	3	4	8	6	21
on spawning grounds	2	2	1	4	9
dumping at sea			2	2	4
should be limited	5	7	10	13	35
Others causes suggested:					
fishing on spawning grounds	1			1	2
seals				1	1
herring offshore	1		2	2	5
Spawning:					
in decline	2	1	1		4
abundant				1	1
Size of herring					
small		3	1	2	6
small in fall			1	2	3
big	1	1	2	1	5
big in fall	1	2	1	1	5
big in spring			1		1
big in summer				2	2
Poor markets			6	17	23
Number of questionnaires received	63	66	117	162	408

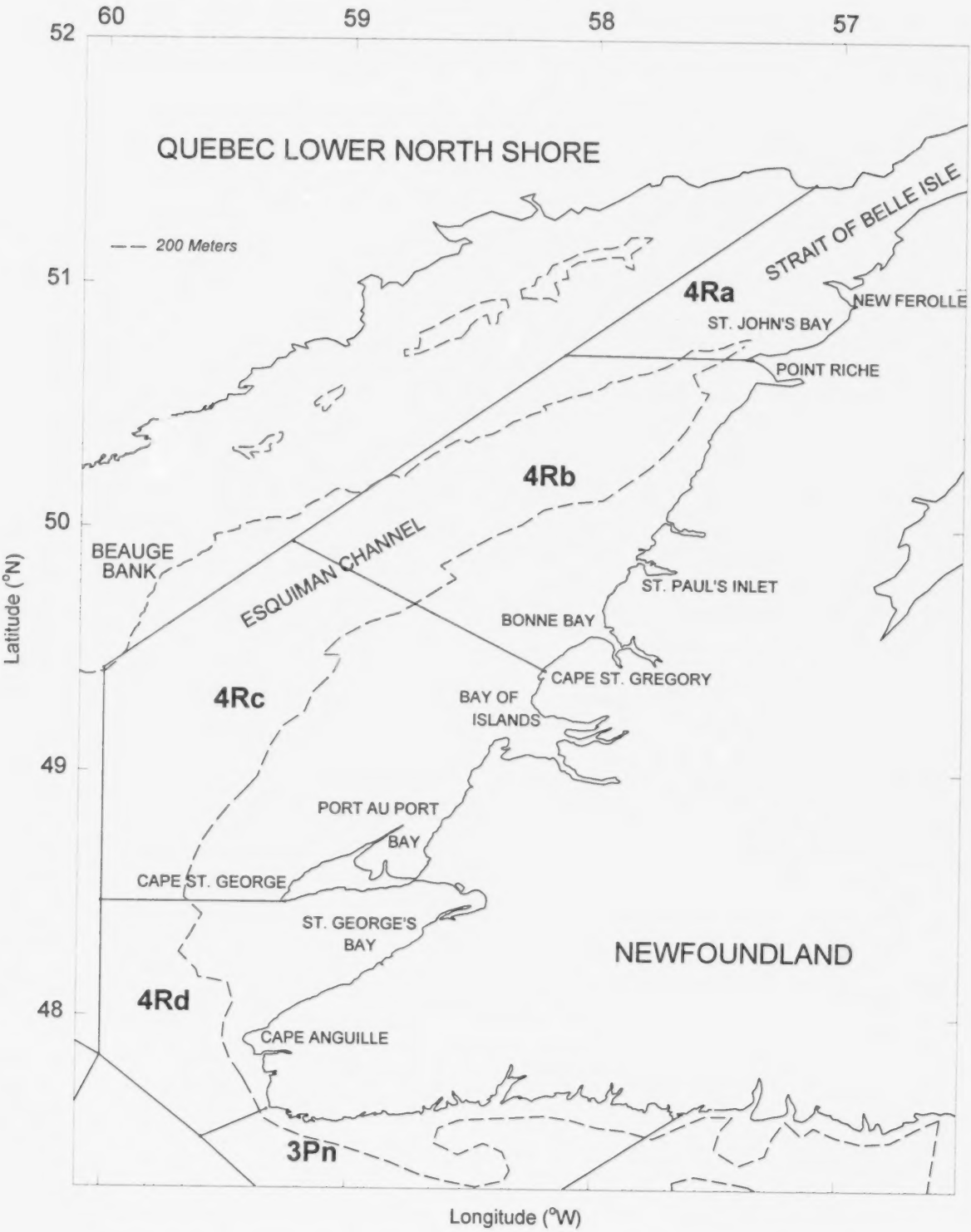

Figure 1. West coast of Newfoundland and herring management unit areas.

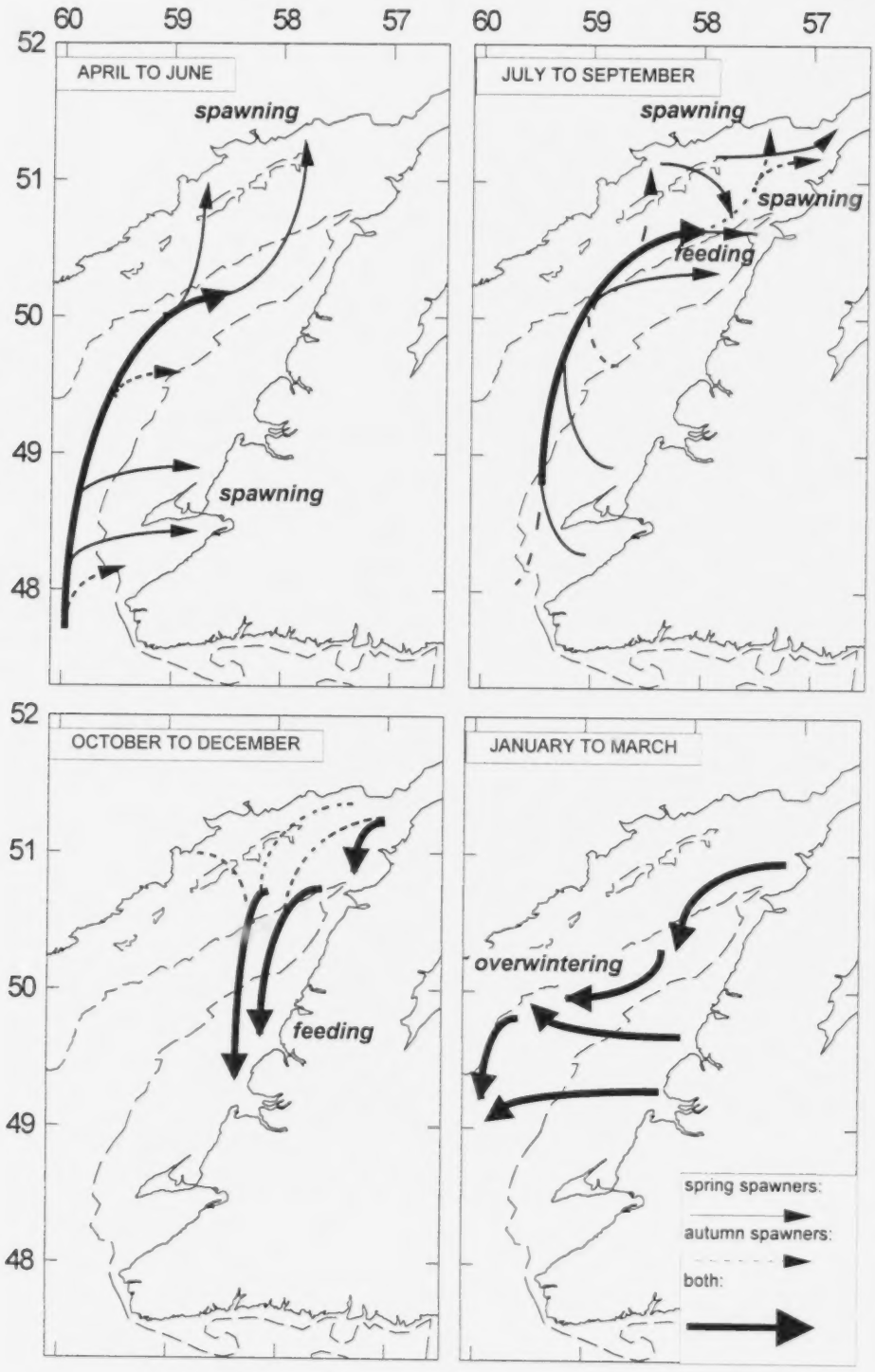

Figure 2. Probable annual migration pattern of spring- and autumn-spawning herring in the north-eastern Gulf of St. Lawrence

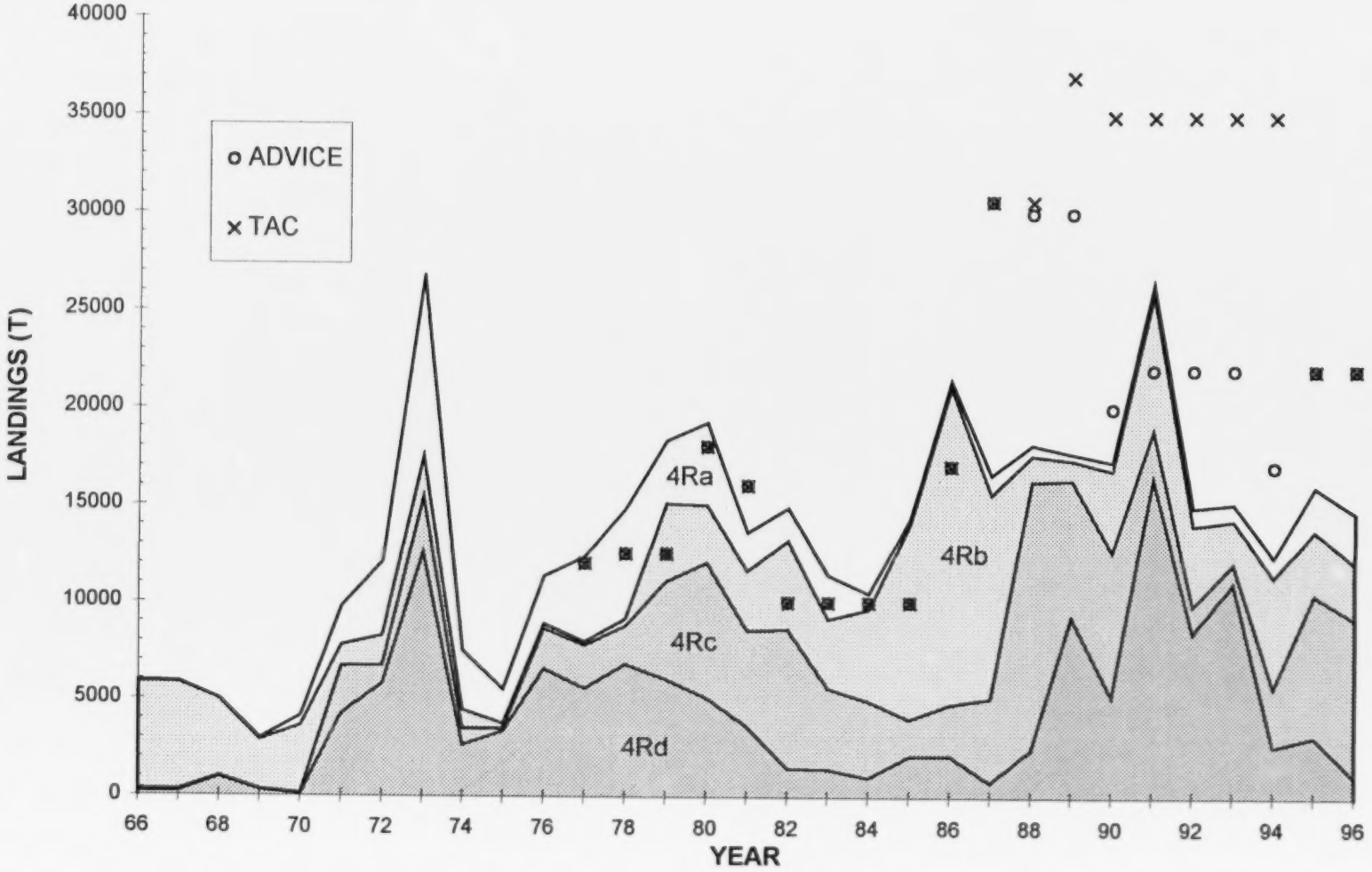

Figure 3. Cumulative commercial herring landings (t) by unit area in NAFO Division 4R from 1966 to 1996. (The advised catch level from the assessments and the final TAC are indicated).

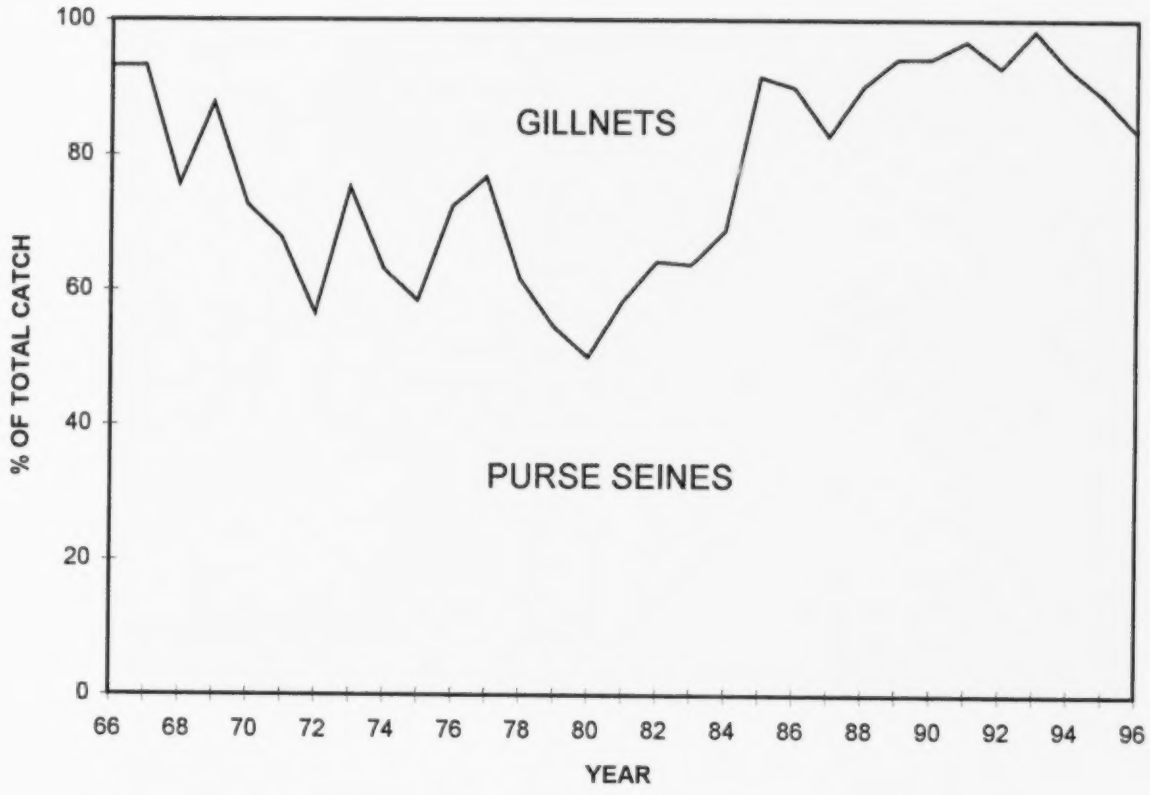

Figure 4. Proportion of total herring landings taken by gillnets and purse seiners in NAFO Division 4R from 1966 to 1996.

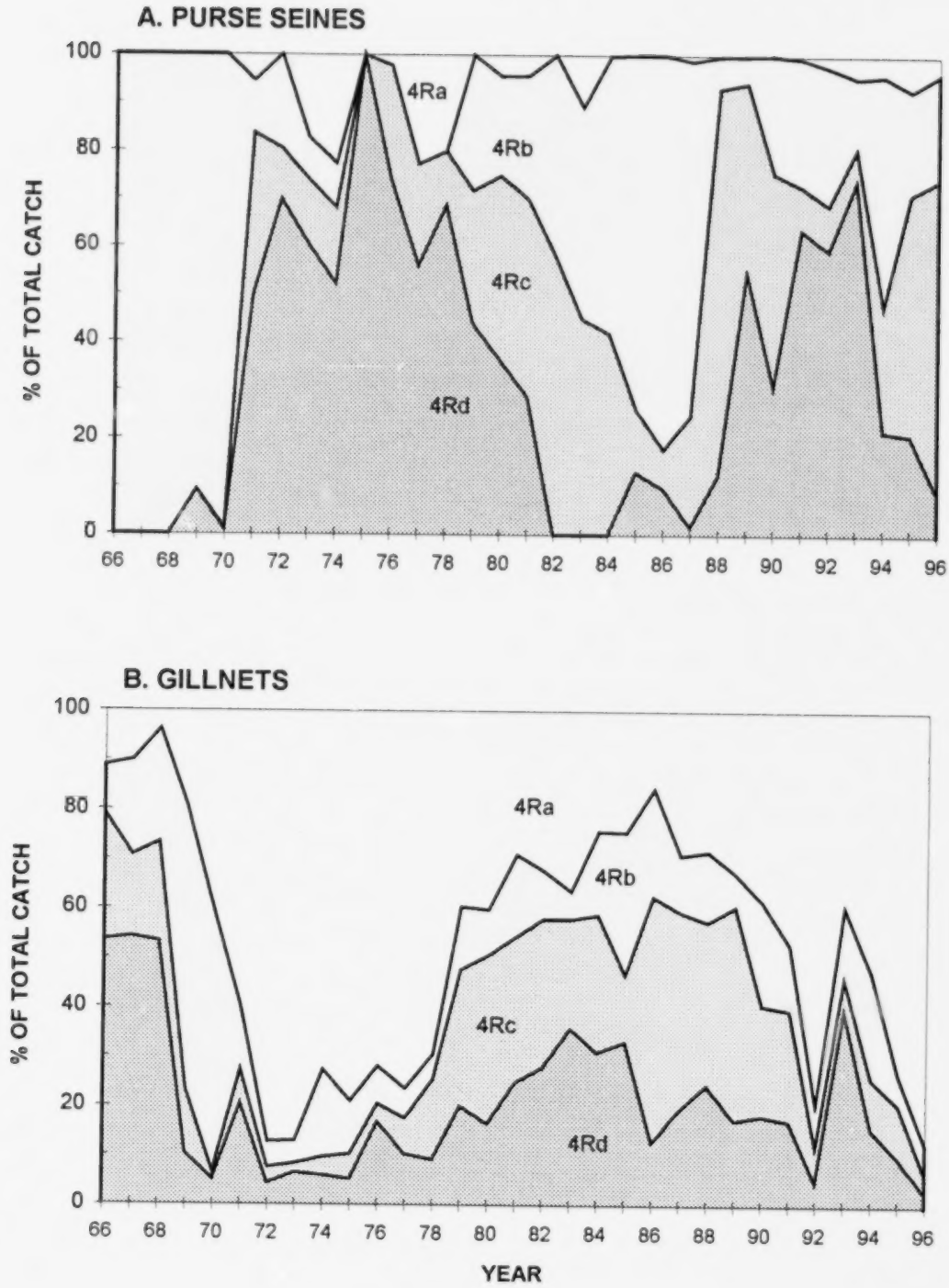

Figure 5. Proportion of purse seine (A) and gillnet (B) herring landings by fishing area in NAFO Division 4R from 1966 to 1996.

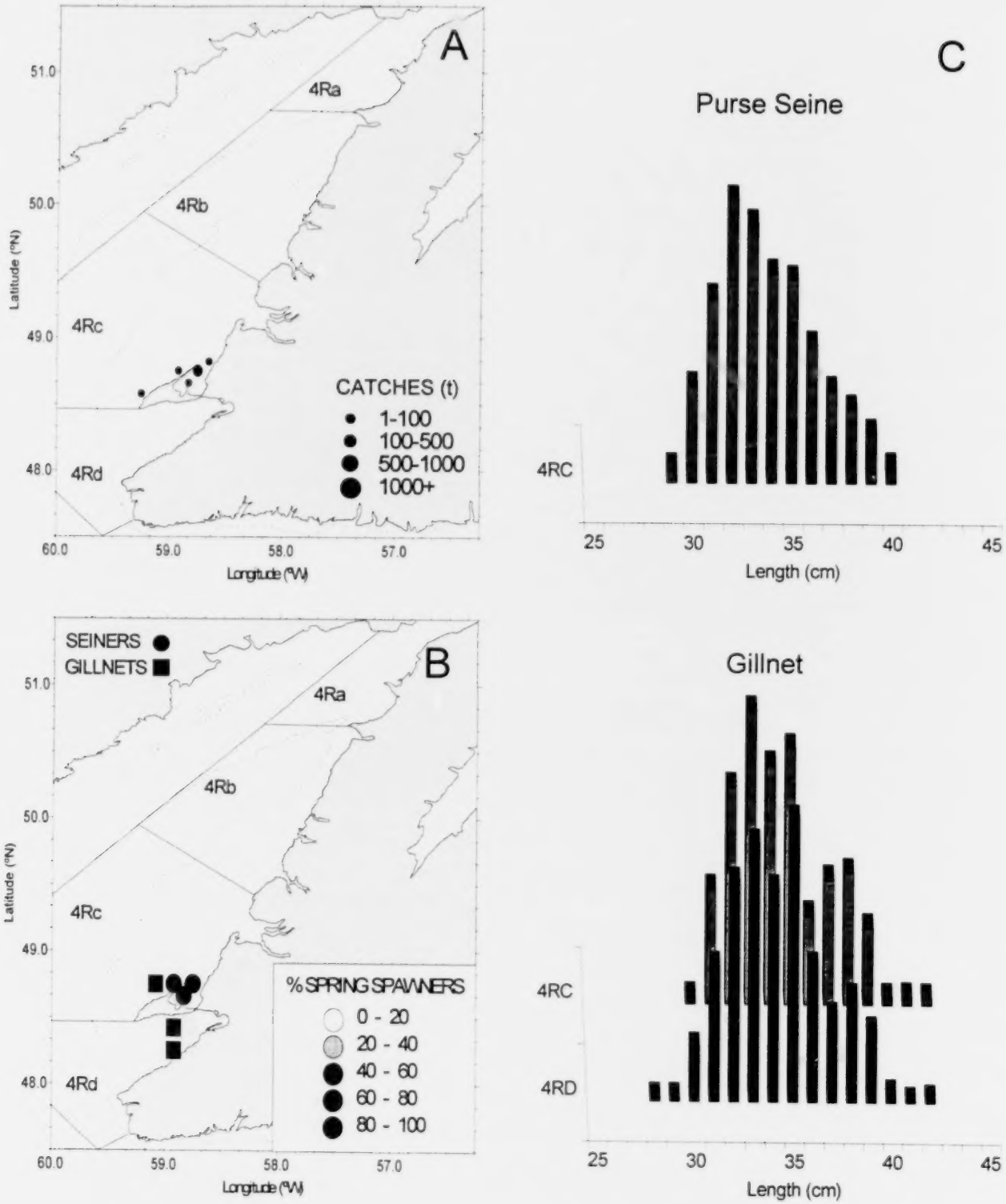

Figure 6a. Distribution of (a) purse seine herring catches, (b) percentage spring spawners for purse seine and gillnets and (c) length distributions by gear and unit area in NAFO division 4R in May 1996. The 200 m depth contour is indicated.

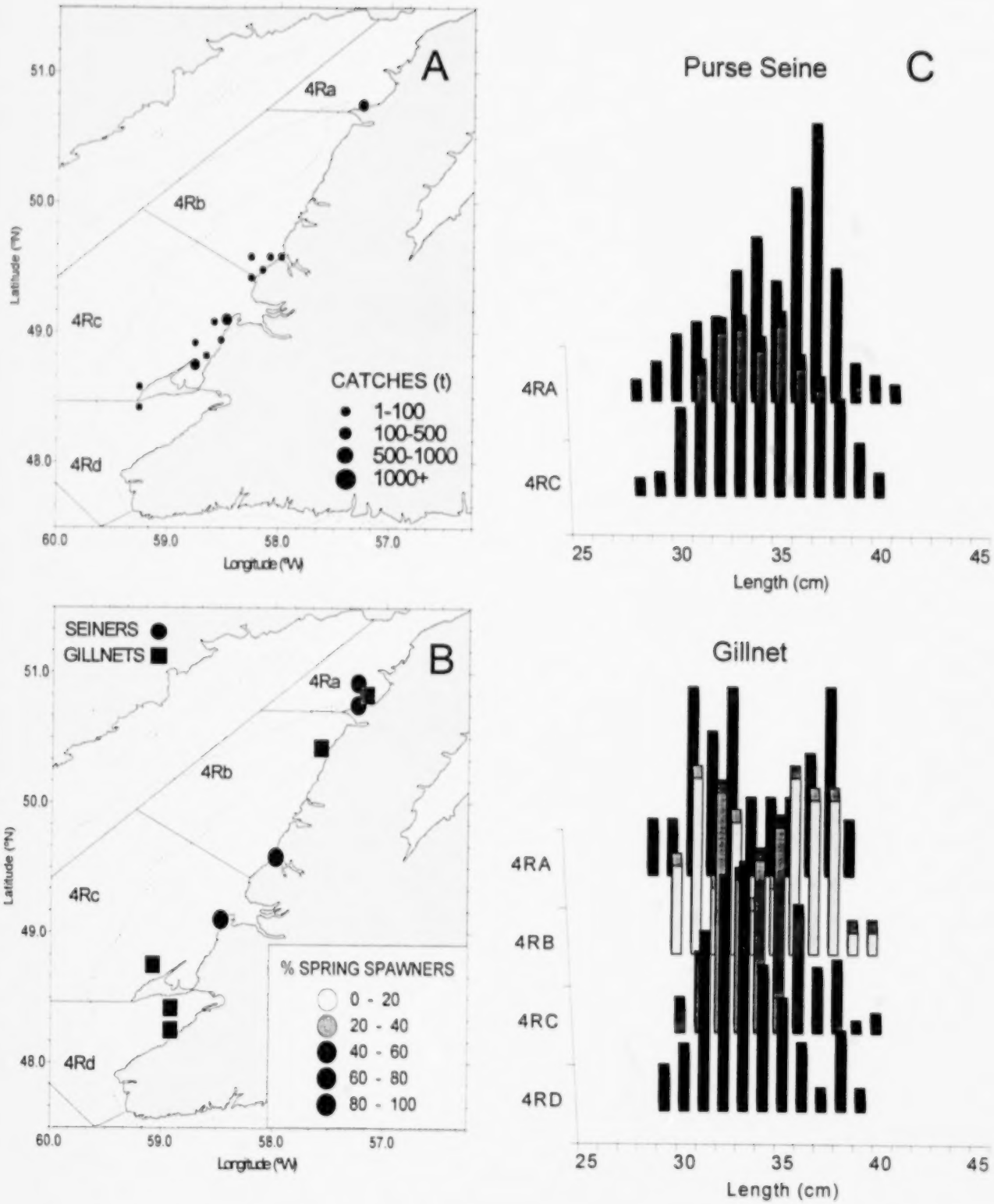

Figure 6b. Distribution of (a) purse seine herring catches, (b) percentage spring spawners for purse seine and gillnets and (c) length distributions by gear and unit area in NAFO division 4R in June 1996. The 200 m depth contour is indicated.

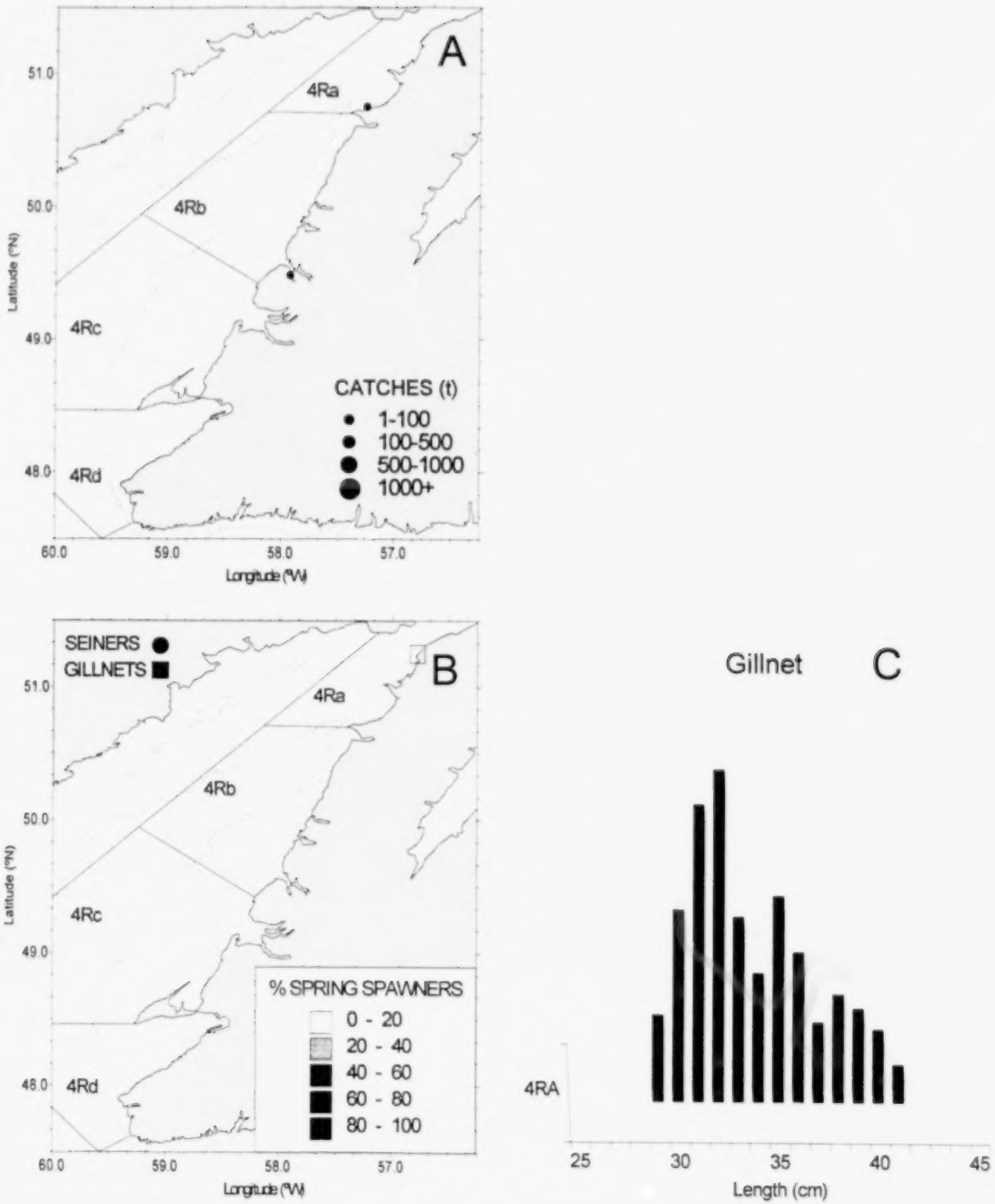

Figure 6c. Distribution of (a) purse seine herring catches, (b) percentage spring spawners for purse seine and gillnets and (c) length distributions by gear and unit area in NAFO division 4R in July 1996. The 200 m depth contour is indicated.

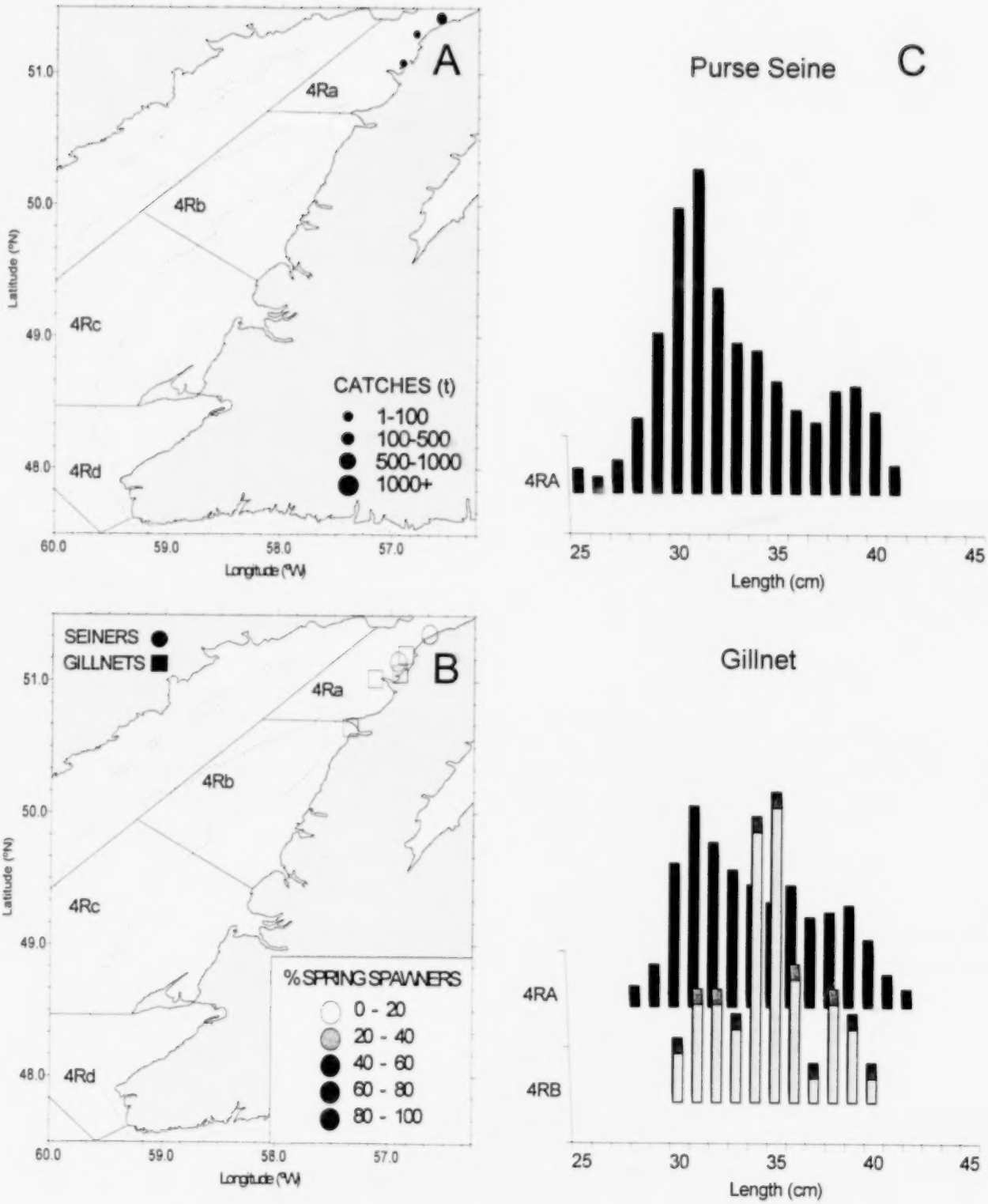

Figure 6d. Distribution of (a) purse seine herring catches, (b) percentage spring spawners for purse seine and gillnets and (c) length distributions by gear and unit area in NAFO division 4R in August 1996. The 200 m depth contour is indicated.

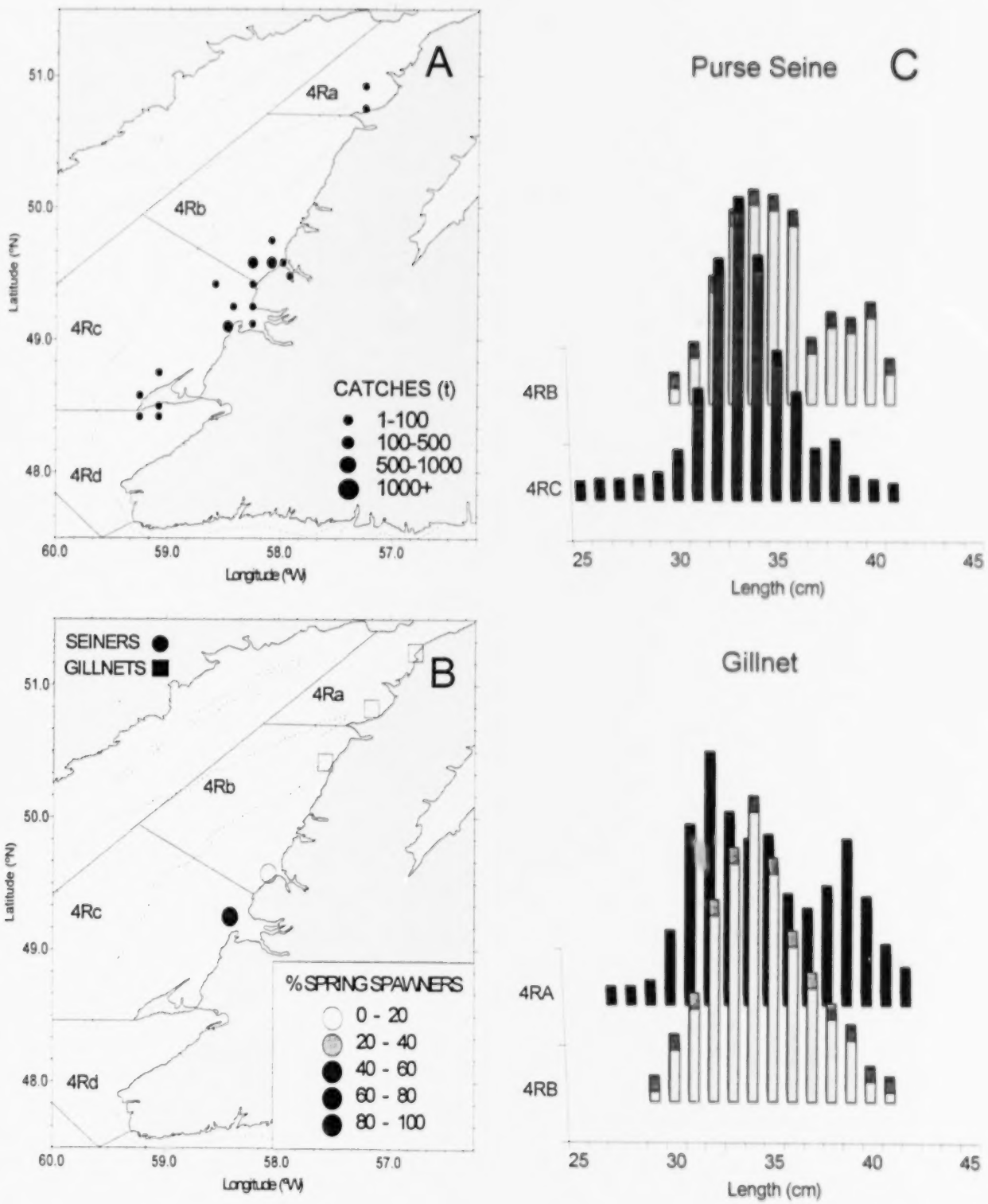

Figure 6e. Distribution of (a) purse seine herring catches, (b) percentage spring spawners for purse seine and gillnets and (c) length distributions by gear and unit area in NAFO division 4R in September 1996. The 200 m depth contour is indicated.

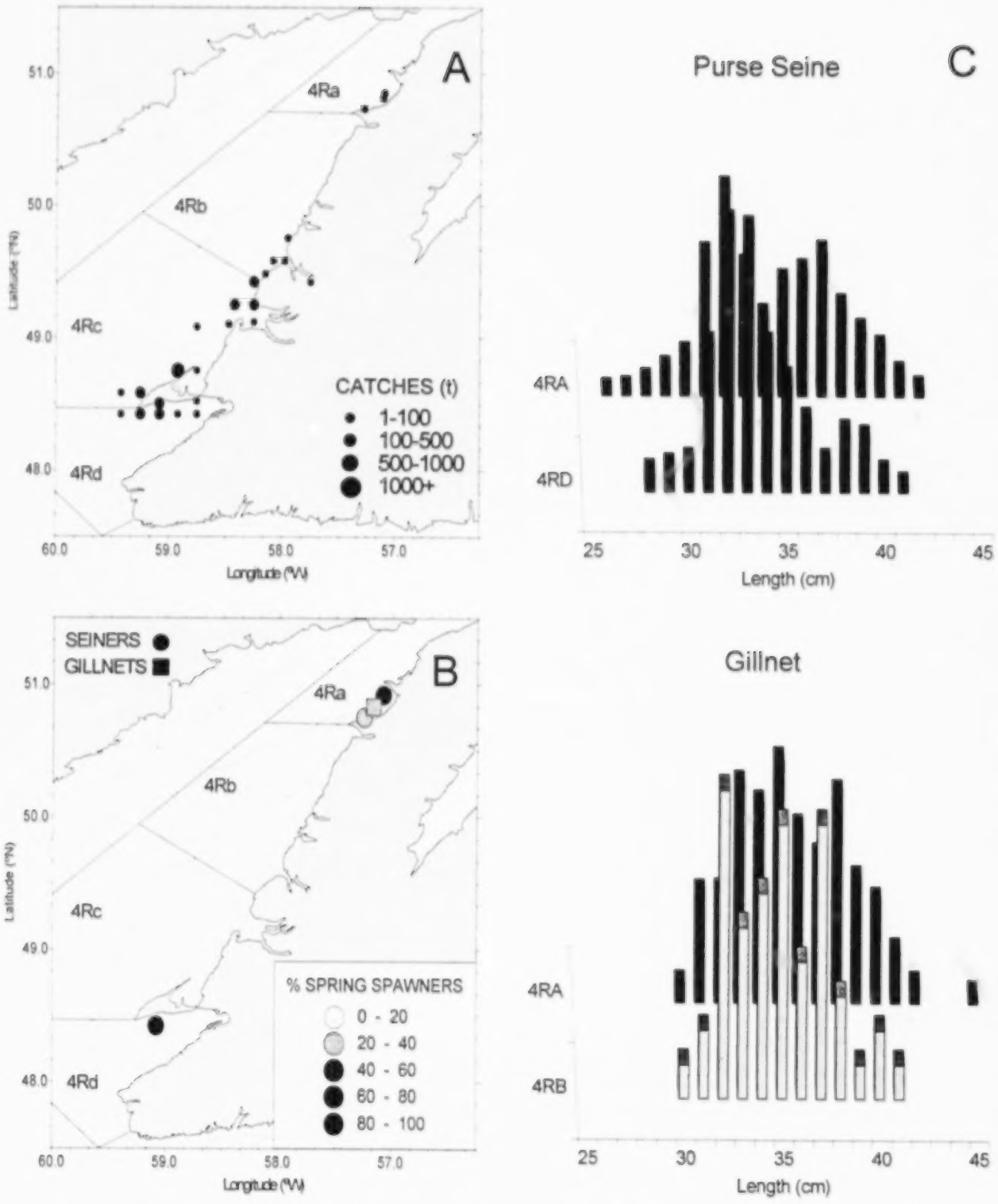

Figure 6f. Distribution of (a) purse seine herring catches, (b) percentage spring spawners for purse seine and gillnets and (c) length distributions by gear and unit area in NAFO division 4R in October 1996. The 200 m depth contour is indicated.

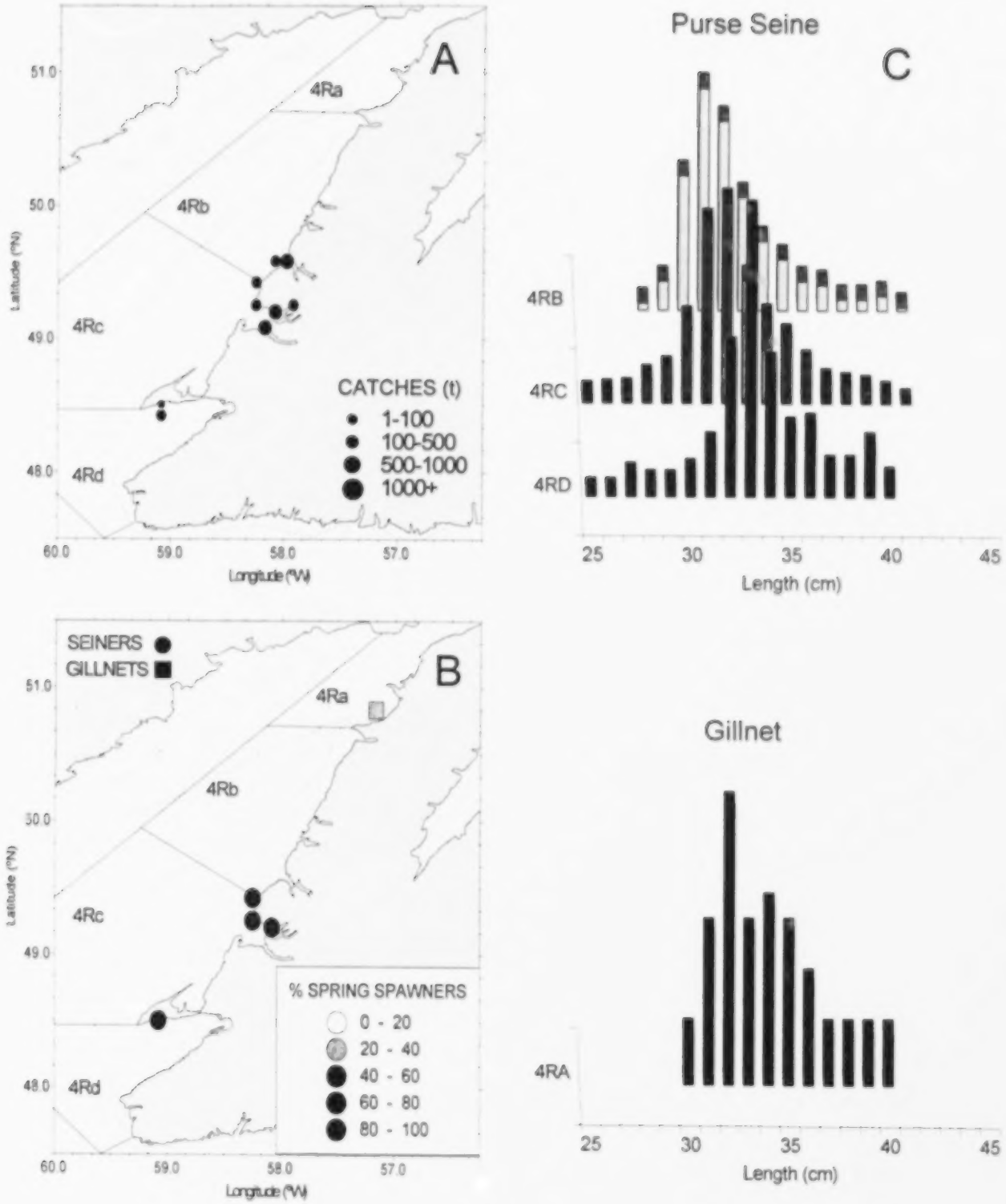

Figure 6g. Distribution of (a) purse seine herring catches, (b) percentage spring spawners for purse seine and gillnets and (c) length distributions by gear and unit area in NAFO division 4R in November 1996. The 200 m depth contour is indicated.

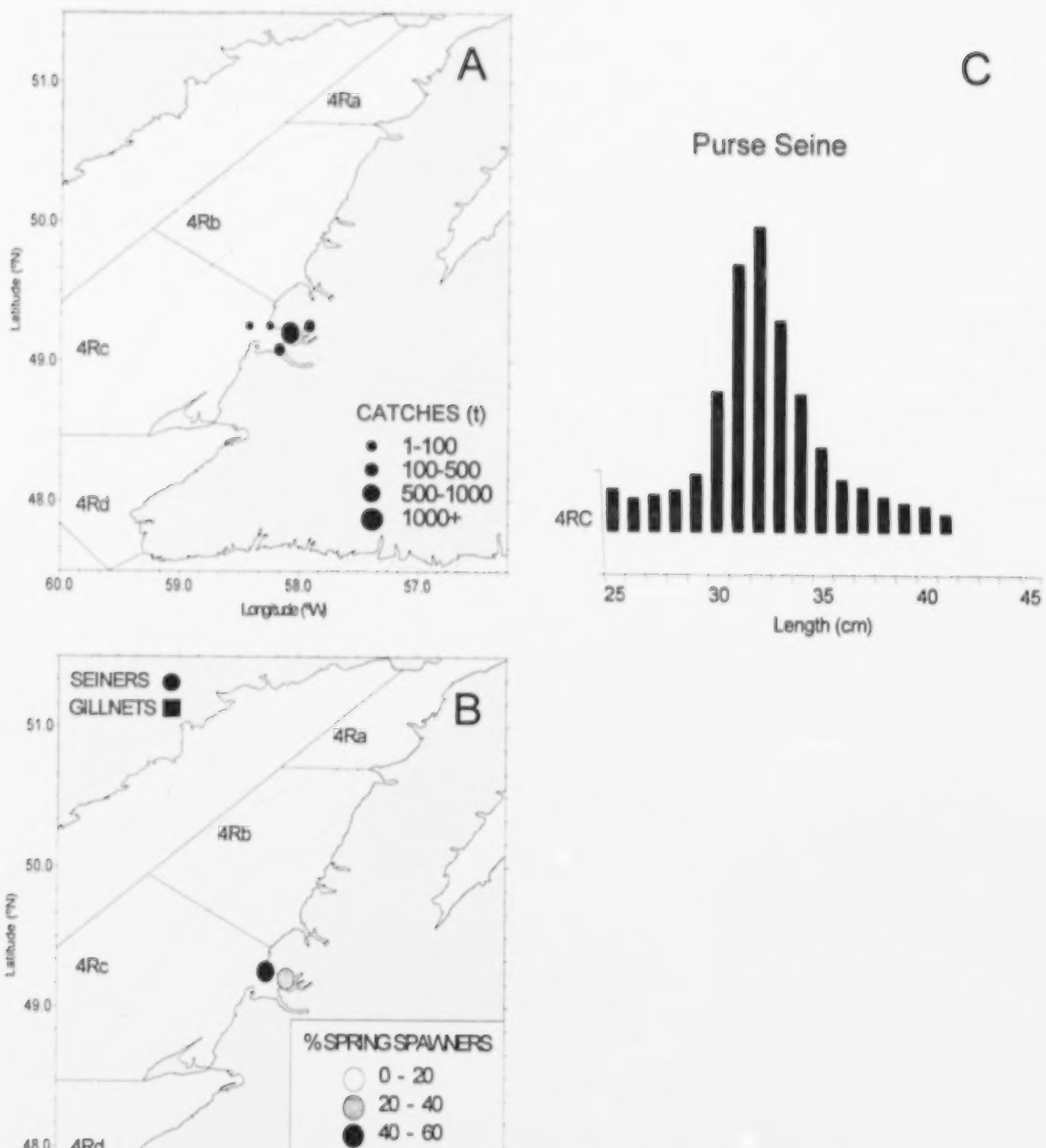

Figure 6h. Distribution of (a) purse seine herring catches, (b) percentage spring spawners for purse seine and gillnets and (c) length distributions by gear and unit area in NAFO division 4R in December 1996. The 200 m depth contour is indicated.

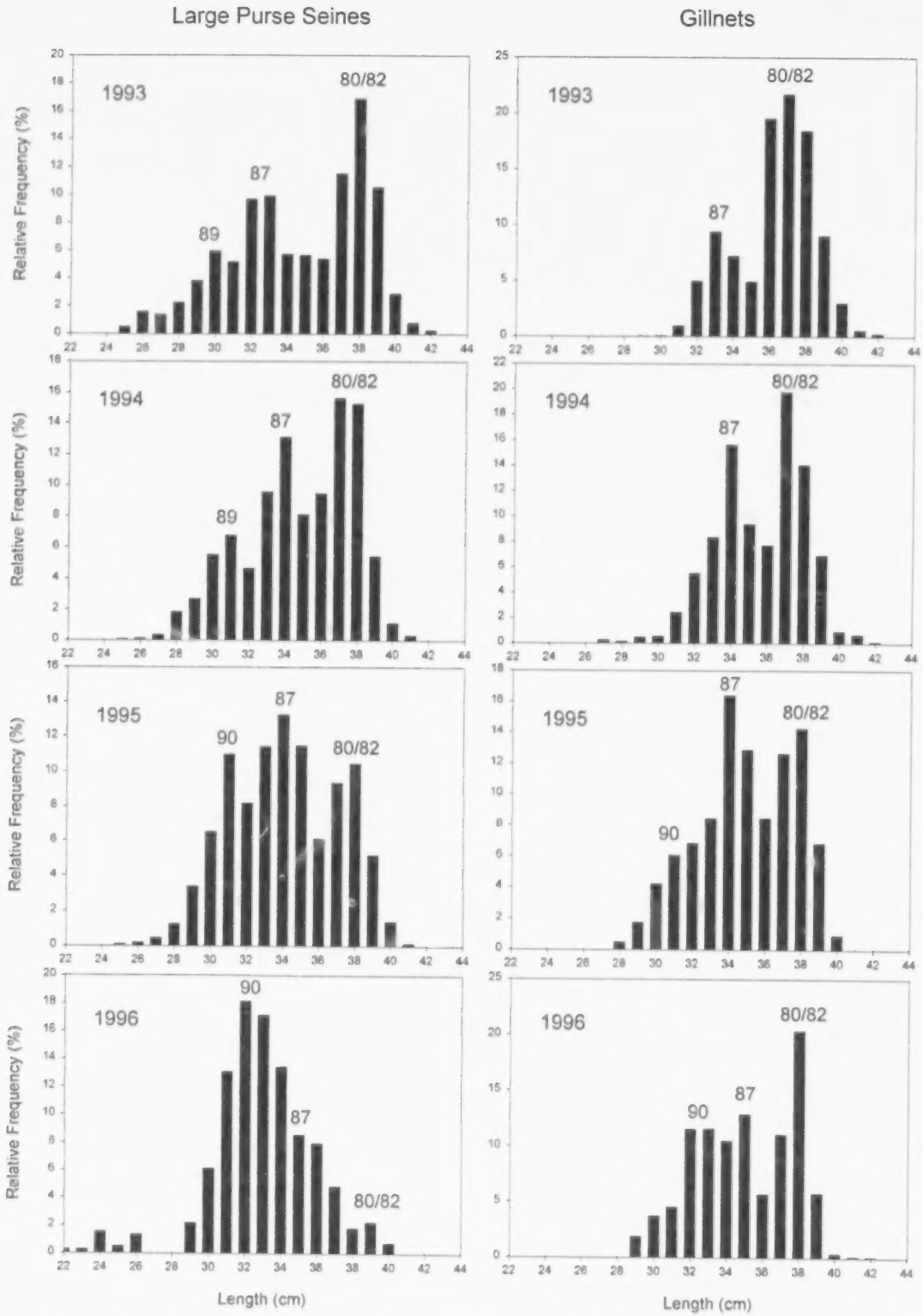

Figure 7. Annual large purse seine and gillnet catch-at-length (%) of 4R spring-spawning herring from 1993 to 1996 (major year-classes are indicated)

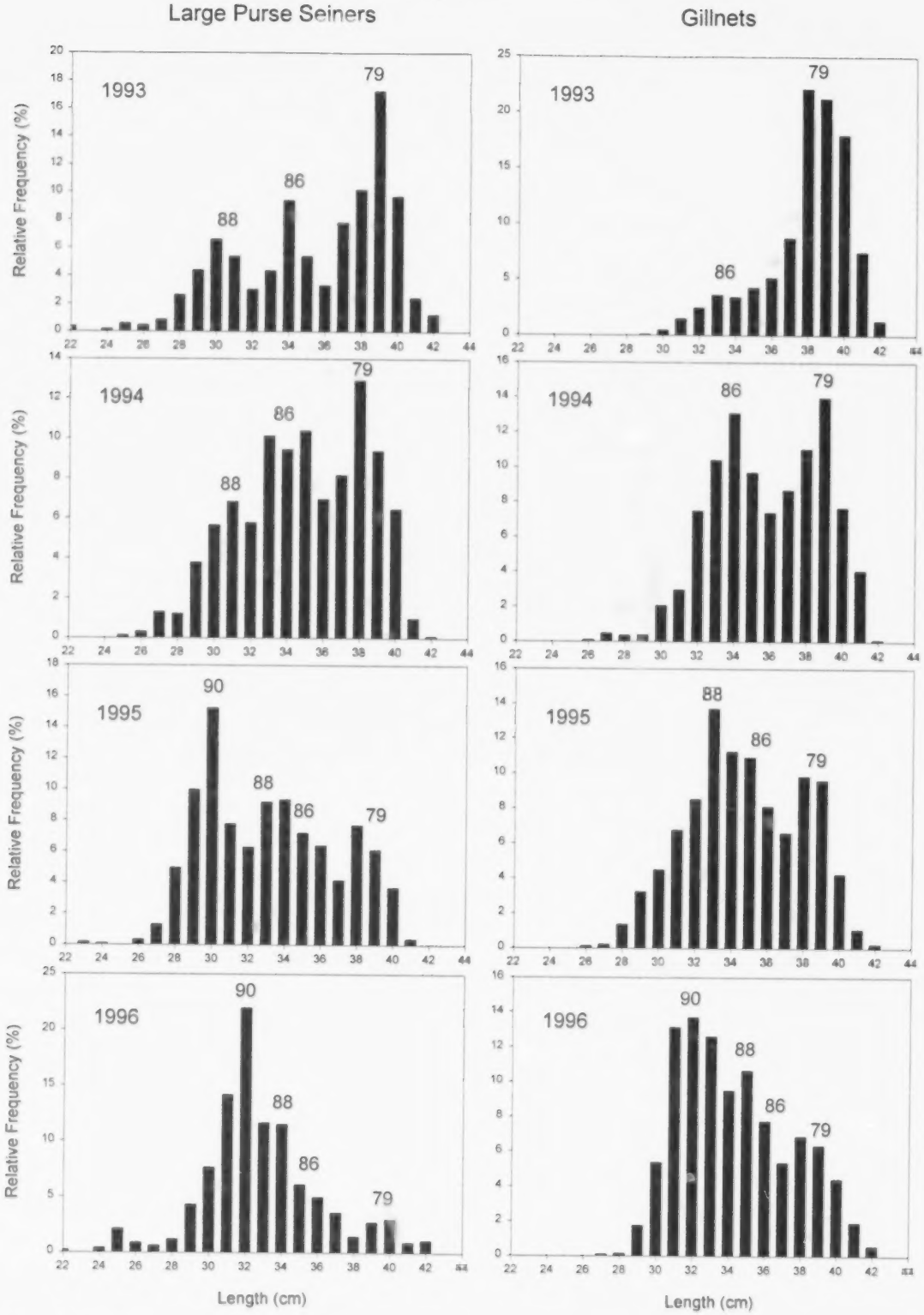

Figure 8. Annual large purse seine and gillnet catch-at-length (%) of 4R autumn-spawning herring from 1993 to 1996 (major year-classes are indicated)

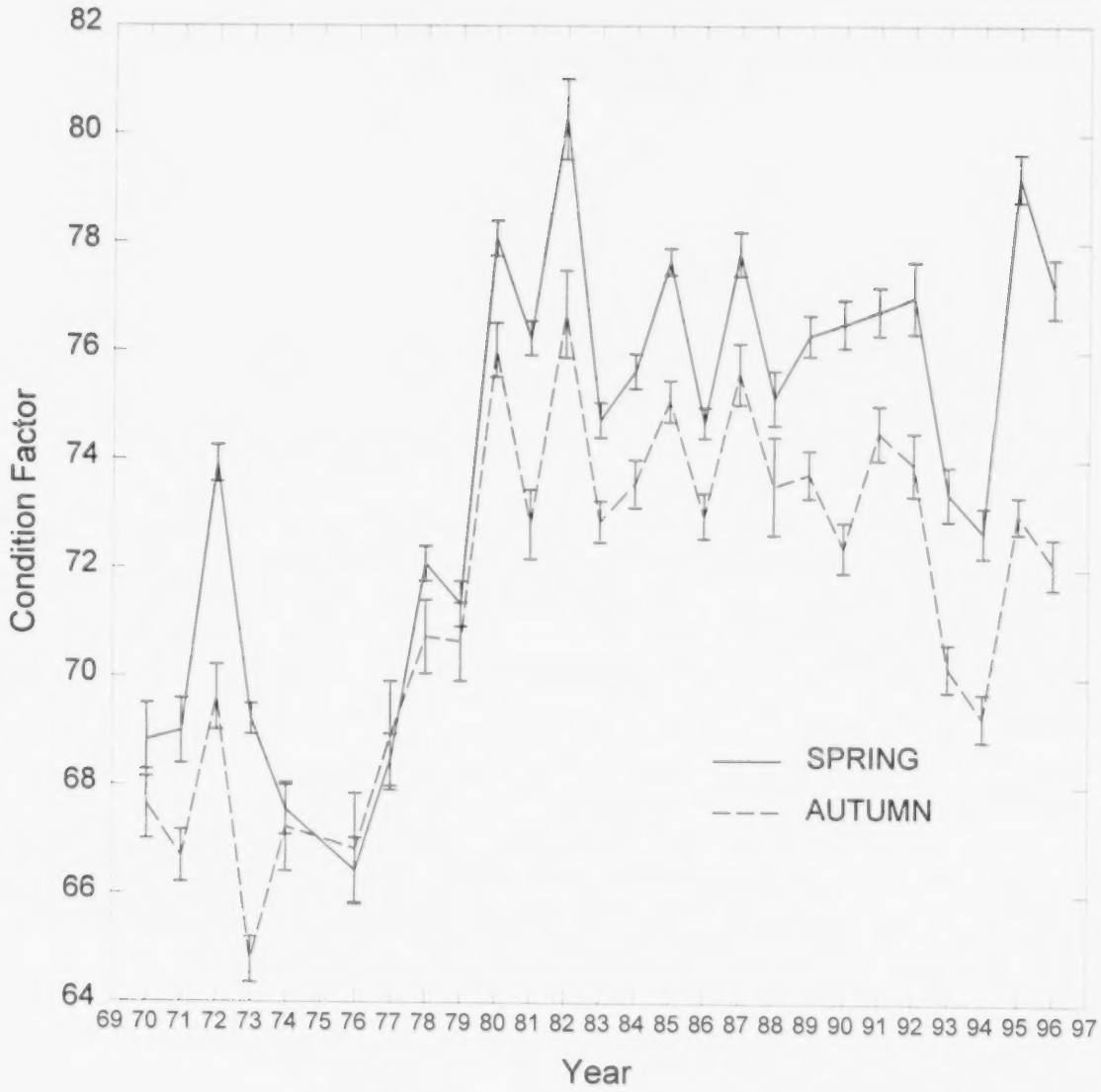

Figure 9. Mean condition factor for spring- and autumn-spawning 4R herring in late fall (Oct-Dec) from 1970 to 1996.

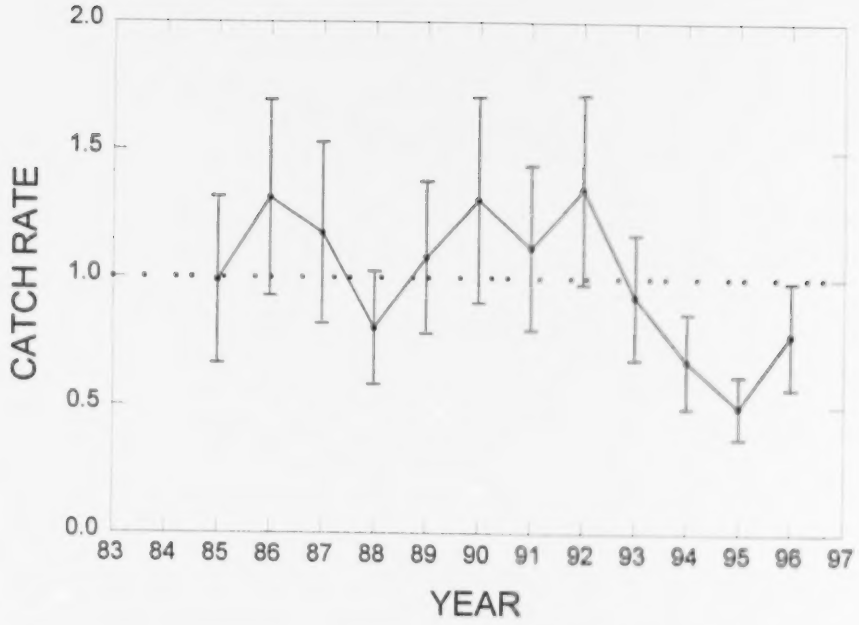

Figure 10. Standardized gillnet catch per unit effort and 2xS.E. for spring-spawning herring in NAFO unit areas 4Rc and 4Rd from index-fisherman logbook data (reference line = mean of the series).

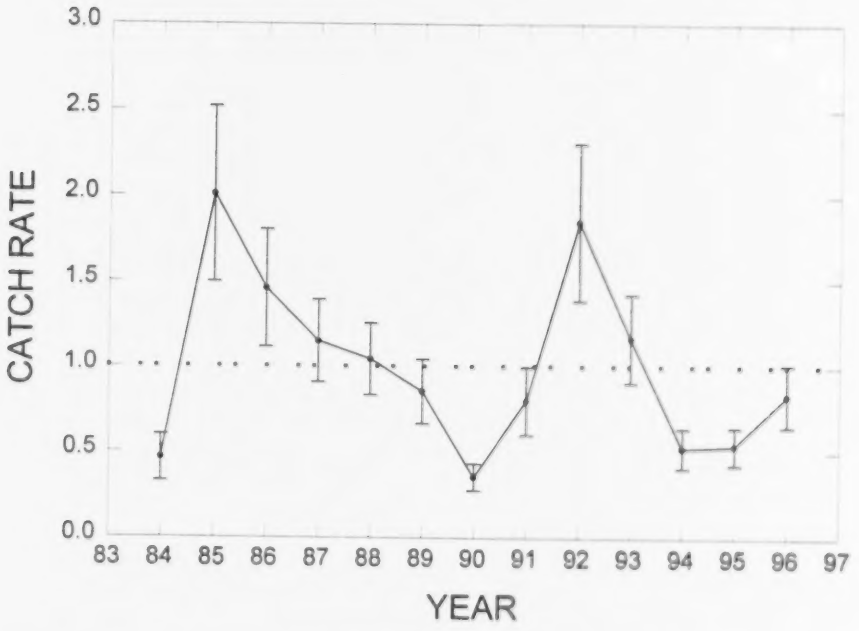

Figure 11. Standardized gillnet catch per unit effort and 2xS.E. for autumn-spawning herring in NAFO unit areas 4Ra, 4Rb and 4Rc from index-fisherman logbook data (reference line = mean of the series).

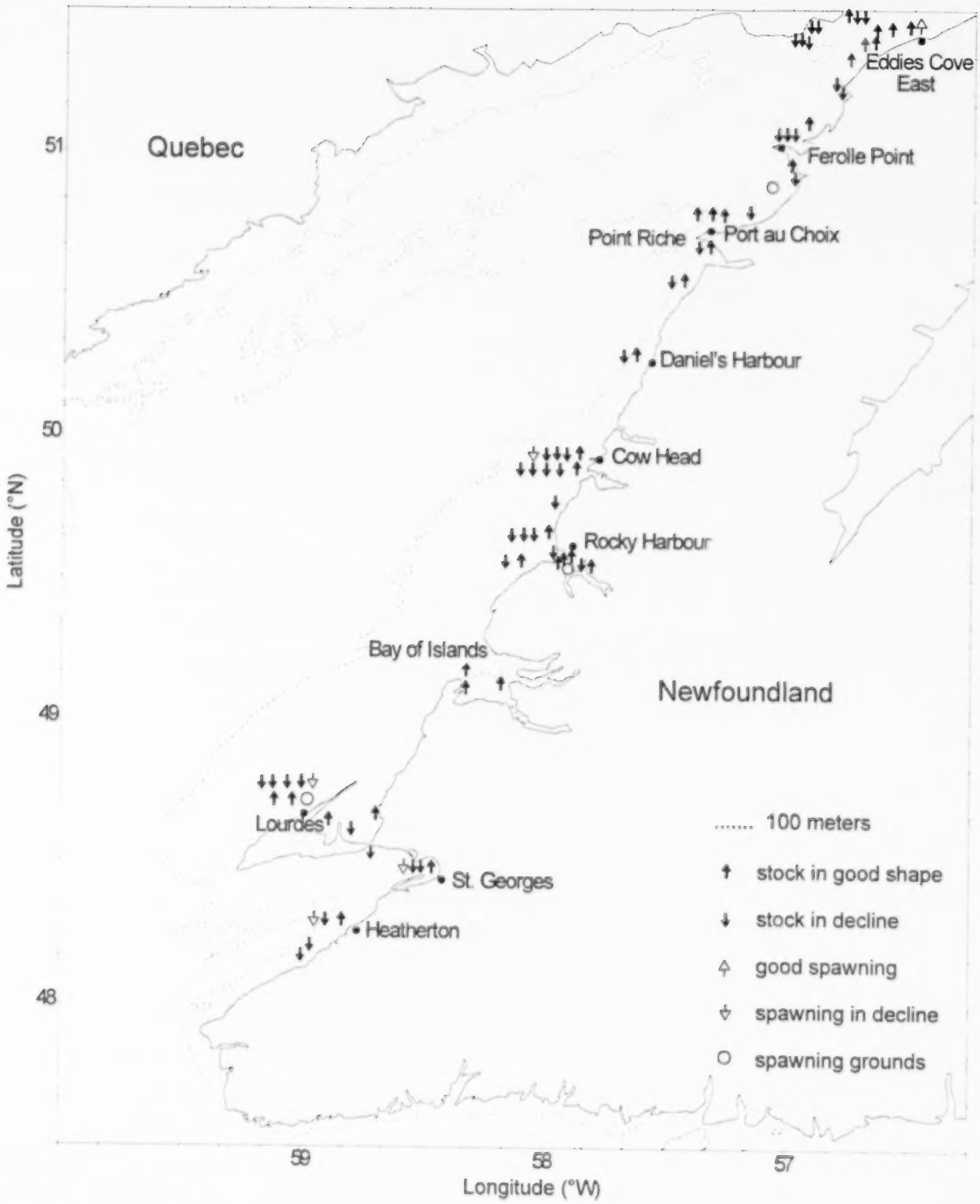

Figure 12. Distribution of inshore fishermen's opinions concerning the state of herring stocks and spawning in NAFO division 4R from 1996 written questionnaires.

Annex 1. Number of herring otoliths read **(bold print)** and commercial landings (t) in NAFO division 4R by gear, area and month in 1996. (Boxed areas indicate sample-landing combinations for the weighting of the catch at age).

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GN	4Ra						1 **48** 253	2 **149** 274	3 **150** 121	4 **193** 438	5 **50** 331	**50** 4	
	4Rb					6 **48** 2	3	9	7 **50**	**97** 106	**50** 9		
	4Rc					8 **179** 37	9 **97** 14						
	4Rd				**97**	**582**	**97** 1				7		

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PS > 65'	4Ra								1 **99** 226				
	4Rb									2 **50** 253	5 193	**50** 1449	
	4Rc					3 **150** 239	4 **247** 487					**199** 1829	6 **50** 1733
	4Rd						27			278	1897		
										7 75	**50** 129	8 **49** 368	

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PS < 65'	4Ra						1 **100** 170	13		2 21	**99** 17		
	4Rb					3 3	263	2		43	262	52	
	4Rc					**50** 241	62			4 **98** 170	407	78	12
	4Rd										367		